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THE EFFECTS OF INFLATION AND INFLATION UNCERTAINTY ON THE LEVEL AND COMPOSITION OF U.K. MANUFACTURING INVESTMENT

A NEOCLASSICAL APPROACH

Submitted by

DIMITRIS KYRIAKIDIS

for the degree of

PhD.

of the University of Bath

1990

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DEDICATION

In memory of my father.

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ABSTRACT

Theory suggests that by reducing the real value of depreciation deductions based on historic cost asset prices, inflation reduces the incentive to purchase depreciable plant and equipment.

This analysis also suggests that the negative effects of inflation on investment will be greater for equipment than structures and will vary according to different initial assumptions about real interest rates and asset purchase prices. Furthermore, it has been argued that increases in inflation uncertainty lead to reductions in business investment, brought about by increased hurdle rates, greater planning costs, and an overall slower rate of economic activity. The objective of this thesis is to provide empirical evidence, necessary to evaluate the importance of these factors, as determinants of capital investment in U.K.

From the data provided in this thesis, four basic conclusions are identified:

1. The empirical evidence supports the hypothesis, that the decline in the real value of depreciation deductions brought about by inflation, leads to a decline in real business investment. Such effects are

substantial, and that failure to account for the interaction of inflation and historic cost depreciation, leads to incorrect predictions of investment.

2. The evidence in this thesis supports the hypothesis that inflation leads to a much greater decline in equipment than structures investment. This result persists over a wide range of assumed economic conditions, indicating that the recent shift in the composition of business investment toward equipment is not explained by increases in inflation.

3. The data also confirm the hypothesis, that the effects of inflation and historic cost depreciation on investment will vary over time. Changes in investment brought about by changes in inflation are jointly determined with real interest rates and asset purchase prices, and proper measurement of such effects is critically dependent on additional economic variables.

4. Finally, the evidence obtained by this research, confirms the hypothesis, that inflation uncertainty is a significant determinant of investment demand. Although these effects are much smaller than the measured effects of inflation and historic cost depreciation on investment, they are nevertheless significant to the explanation of recent business investment behaviour.

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CHAPTER I

INTRODUCTION

One of the trends in capital formation in recent years concerns the dramatic increase in the portion of aggregate investment devoted to purchases of producers durable equipment. In 1960, for example, equipment expenditure represented 62 percent of total investment in the U.K. manufacturing sector. By 1970, the portion of aggregate investment devoted to equipment had risen to 69 percent, and by 1980, equipment expenditure represented 77 percent of total investment. The net effect of this trend in investment composition has been a significant increase in the employment of equipment capital relative to structures capital, reflected in a general decline in the average economic size of the U.K. stock. A similar trend has been experienced in the United States as well. Feldstein (1981a) suggests that the disproportionate increase in equipment capital has lowered the marginal productivity of the aggregate capital stock and thereby contributed to the decline in productivity.

Hendershott and Hu (1981c, 1981e), Feldstein (1980a, 1981a), and Kopcke (1981) have argued that the recent decline in net investment behaviour in most western countries is related to the effect of inflation on the real opportunity cost of business investment. These authors note that under existing tax laws, the depreciation of plant and equipment that firms may claim in calculating taxable income is limited to the original or "historic" price of the asset. Because annual depreciation deductions are not adjusted when the replacement cost of an asset increases, inflation lowers the real value of tax depreciation deductions by reducing their effectiveness in shielding nominal income flows from taxation. Hendershott and Hu, Feldsein and Kopcke argue that the increase in the effective rate of taxation brought about by the combination of inflation and historic cost depreciation leads to an increase in the opportunity cost of employing depreciable plant and equipment and a decline in investment. Moreover, these authors assert that a given increase in the rate of inflation reduces the real value of depreciation deductions differently for structures than for equipment, thereby distorting the relative opportunity cost and composition of investment in equipment versus structures.

In summary, Hendershott and Hu, Feldstein, and Kopcke maintain two separate, but equally important, hypotheses regarding the effect of inflation on investment: (1) by raising the opportunity cost of investment in all classes of assets, inflation reduces the aggregate demand for capital goods relative to that which would exist in a non - inflationary environment, and (2) by distorting the relative cost of investment in different classes of assets, inflation contributes to changes in the composition of business investment.

These authors disagree, however, on the direction of the relative distortion between equipment and structures. Hendershott and Hu argue that any changes in tax depreciation incentives caused by inflation have more of an effect on equipment investment, biasing the investment decision toward structures. Similar results were obtained by Auerbach (1979). Bradford (1981) appears to agree with this conclusion also. In contrast, Feldstein (1981a) and Kopcke (1981) assert that the interaction of inflation and historic cost depreciation leads to an increase in the share of investment devoted to equipment. The results of Feldstein and Kopcke are consistent with recent trends in investment composition, whereas Hendershott and Hu's work is not. Unfortunately, the controversy related to the effects of inflation on investment composition has not been fully resolved though the bulk of the evidence appears to substantiate the results of Hendershott and Hu.

In addition to the effects of inflation on Investment brought about by historic cost depreciation rules, Malkiel (1979), Cuckierman (1980), Friedman (1980), and Levi and Makin (1979) suggest that inflation uncertainty has played a significant role in discouraging real capital investment. Increases in inflation uncertainty, measured by changes in the variance of forecasts of expected inflation, reduce investment by (1) increasing the hurdle-rate on investment projects, (2) increasing the time and expense required to investigate and plan uncertain ventures, and (3) reducing the general level of output. Evidence on the effects of inflation uncertainty on savings behaviour, however would seem to dispute the conclusions. For example, Wachtel (1979) finds that an increase in inflation uncertainty increases savings which should lead to an increase in investment. Although the effects of inflation uncertainty on investment have not been explicitly modeled, such uncertainty appears far from neutral. To date, however, economists have not attempted to measure directly the effects of inflation uncertainty on investment, leaving this controversy unresolved.

The major problem in assessing the effects of inflation and inflation uncertainty on capital formation is the general absence of econometric evidence on this topic especially in the United Kingdom. Feldstein (1981a) and

Corcoran (1979) provide some evidence that inflation and historic cost depreciation are responsible for the decline in net investment, but the econometric results in both studies suffer from methodological problems. Empirical verification of these relationships has been limited primarily to the construction of simple hypothetical examples designed to characterize the decline of depreciation deductions under alternative scenarios of inflation. Although the results of these examples are consistent with theoretical predictions, they do not provide sufficient evidence to assert that inflation and historic cost depreciation rules have affected historical patterns of investment. Unfortunately, the effect of inflation uncertainty has not received even this simple level of attention. Essentially, the hypothesis that inflation and inflation uncertainty distort the level and composition of investment has not been subjected to rigorous empirical examination.

1.1 The Objective of the Study

The purpose of this research is to measure the effects of inflation and uncertainty on the level and composition of manufacturing investment. The methodology is based on the econometric estimation of neoclassical investment equations for the U.K. manufacturing sector. Separate equations are estimated for equipment and structures for the period 1963 - 86. Explanatory variables in the models are constructed to allow for explicit treatment of inflation expectations as well as inflation uncertainty.

The research is designed to answer four basic questions: (1) Does the interaction of inflation and historic cost depreciation rules lead to a decline in manufacturing investment ? (2) Does inflation reduce equipment investment more than structures investment ? (3) Do the effects of inflation on investment vary over different sets of economic assumptions ? and (4) Do increases in inflation uncertainty reduce manufacturing investment ?

This research is unique for two reasons. First, the work contributes to the resolution of the controversy surrounding the effects of inflation on investment composition. The hypothesis of Feldstein and Kopcke that inflation biases investment toward equipment is shown to be ambiguous in theoretical terms. This ambiguity is resolved, however, when the effects of inflation on relative costs of investment are examined within the framework of the user cost of capital as shown by Hendershott and Hu (1981c). The analysis also discusses the conditions under which the predicted composition effects of inflation could be reversed, an idea that has not been discussed in the literature.

Secondly, and most importantly, the empirical results in this study represent the only econometric evidence available to measure the significance of inflation and inflation uncertainty on the level and composition of manufacturing sector in the U.K. The evidence provided by this research suggests that both of these factors are important elements in the recent decline in net investment, and that failure to account for these variables leads to serious specification errors. No other study has documented this fact and for this reason, the empirical results presented in this thesis represent a substantial contribution to the economic analysis of capital investment.

1.2 Limitations of the Study

A number of limitations may be identified in this empirical work:

1) There is no attempt to supplement this empirical investigations by interviews or questionnaires.
2) No attempt is made to evaluate time series observations for individual companies because of the relative short - time period of data available.

3) Although data availability has not been a major problem in this research it has limited however the sample period.

1.3 Overview of the Study

The remainder of this thesis is divided into eight sections, **chapter II** deals with a number of issues of inflation, in an attempt to improve our understanding of the environment under which business firms operate. In particular attention is focused on the real effect taxes have on firms in an inflationary economy. Furthermore evidence are presented on the effect of the inflation on interest rates, and the negative impact it has to the prices of common stock.

Chapter III presents several recognized variations of the theory of investment behaviour. Each method seems to provide a reasonable explanation of investment behaviour. However because of the focus of the study only a short review of the non - neoclassical models is presented while the neoclassical approach is described in detail.

Chapter IV presents the theoretical results which link inflation and historic cost depreciation to the level and composition of investment, with the use of three different methodologies.

Chapter V discuss the limited empirical evidence on the relation of inflation to investment and the importance of inflation uncertainty in explaining investment demand.

Chapter VI provides a detailed description of the empirical methodology used in this research.

Chapter VII makes an attempt to link inflation uncertainty and investment indirectly through output. Towards that the natural rate hypothesis is employed.

Finally **chapters VIII** and **IX** present the actual results and main conclusions derived from the previous analysis and specify directions for further research on the effects of inflation in the firms' behaviour.

CHAPTER II

ISSUES OF INFLATION

The purpose of this chapter is to highlight the effects of inflation on the economic environment at which business firms are operating. The first section starts by providing a brief discussion of the effects of inflation and taxes on business income. Section 2 deals with the concept of the potential wealth distribution due to unanticipated inflation, and sections 3 and 4 analyse the effect of inflation on interest rates and the negative impact it has to the prices of common stock.

2.1 Effects of Inflation and Taxes on Business Income

Inflation affects the real tax burden of corporations, where the tax system is based on nominal values. This is true in most modern countries. The problem of inflation accounting has attracted significant attention in accounting literature. In a summary of inflation accounting issues, Vasarhelyi and Pearson (1979) present the basic taxonomy of the historically based accounting versus valuation (or replacement) based accounting, as well as a classification of the methods of research. Discussion regarding the reporting of inflation in the United Kingdom is given by Piper (1979), while a more general analysis of accounting

treatments in continental Europe is given in Schoenfeld (1979).
The survey of literature in this section deals with the economic implications of different accounting techniques rather than with the details of accounting methods.

On a theoretical level, it is shown by Stiglitz (1981) that the real effect of taxes on firms in an inflationary economy is created primarily by a tax system which is not fully indexed for inflation. In particular, Stiglitz (1973) claims that a fully indexed tax system will have a neutral effect on the firm. Stiglitz's condition for a neutral system is:

(a) Depreciation must be at replacement cost and at the "correct" rate;
(b) Taxes on the interest rate must apply to real interest rates, and only real interest rates are tax deductible;
(c) Capital gains and losses must be taxed (at full rates) on an overall basis, rather than on a realisation basis.

The above conditions are consistent with those specified in an earlier work by Sandmo (1974), that analysed the effects of corporate taxes on investment incentives.

The main aspects of nominal corporate income taxes discussed in economics and accounting literature are (a) the treatment of depreciation and allowances for tax purposes, and (b) the treatment of valuation of the inventory stock and the implied cost of material employed in calculating the cost of goods sold.

Depreciation allowances based on historical costs tend to underestimate the real cost of capital services used by the firm. This has two effects :

(1) The accumulated depreciation fund is lower than replacement costs and will not therefore be sufficient to replace the old machines;

(2) The fact that costs of capital service are underestimated, leads to overestimation of the firm's real profits. As a result, the tax liability of firms increases in real terms, without an increase in real economic profits. Therefore after-tax profitability declines.

In inventory valuation, the cost of materials is calculated using either the first-in-first-out (FIFO), or the last-in-first-out (LIFO) method. If the FIFO method is used, the costs of materials, which are based on historical purchase prices, are underestimated and real profits are overstated. This, again, leads to an excessive tax on corporations in a period of inflation. If the LIFO method is used, costs of materials are evaluated in current (or last) prices and thus presented approximately the replacement value of the materials used. This aspect of accounting practices in the United States was discussed by Davidson and Weil (1976), and in United Kingdom a detailed analysis was given by the Sandilands Report (1975). More recent discussions are presented by Feldstein and Summers (1978), Arak (1980) and Gonedes (1981).

With regard to the effect of taxation and inflation on depreciation allowances, the use of book value rather than replacement value depreciation, tends to reduce the real value of depreciation allowances compared with allowances in a stable economy. This has lead some to suggest replacement-cost depreciation rather than historically based depreciations, (see, for example, Davidson and Weil (1976)). Others, such as Landskroher and Levy (1979), have suggested and discussed methods of accelerated depreciations in which expenditures on assets are depreciated (and deducted from income before tax) over shorter periods.

Two other aspects of the effects of taxation and inflation on taxation of corporate income are the deductibility of nominal interest expenses and the capital gains tax. While the taxation of nominal interest leads to excess taxation of lenders, it tends to benefit borrowers, who can deduct their full interest payments from their taxable income. This is particularly true when the interest rate is not fully adjusted, according to the modified Fisher effect. For example, consider the case where interest is adjusted according to the classical Fisher effect, $i = r + \pi$, where r and i denote the real and nominal interest rates and π denotes the expected inflation rate, which is equal here to the actual inflation rate. The after-tax rate for borrowers will decline from $r(1-t)$ to $i(1-t) = r(1-t)-\pi t$. The actual gain is much higher if the firm has long-term debts and the current inflation was not expected (so that the interest on the firm's loans does not reflect the expected inflation). As suggested by Feldstein and Summers (1978), firms in the United States have benefited significantly from their net debtor positions.

Section 2 deals in more detail with the concept of the potential wealth distribution due to unanticipated inflation.

With regard to capital gains taxes, Feldstein and Summers (1978) argue that taxes paid by Stockholders on capital gains and dividends, as well as taxes on interest payments by suppliers, should be considered part of a corporation's overall tax.

In a detailed calculation for the year 1977, Feldstein and Summers determined that while the direct corporate tax was 42.5 percent of corporate income taxation on dividends, taxation of interest income and capital appreciation raised the tax rate to 66.3 percent. The extra tax attributable to inflation was about 60 percent of the corporate tax for 1973-77. The results, however, of the significant increase in the corporate tax burden owing to inflation are not consistent with the study by Gonedes (1981), who for 1947-74 found that the tax-effects hypothesis "that real rates of income tax will vary directly with the rate of inflation" is not supported by the data. He explains these surprising results for a nominal tax system by saying that "indirect indexation" was attained by alternative options, such as liberalisation of depreciation rates. An additional reduction in taxes was attained by the increased use of debt-induced tax shelters.

In evaluating excess taxation of the corporate sector, one should consider several implications. First, excess taxation on corporations may have been important causes of the decline in the stock market and the decline is corporate investment in the 1970's.

Second the induced reduction in profitability also reduced the demand for investment and the desired demand for loans by business firms. This reduction on corporate loan demand in real terms suggests that the real return to savers will decline with an increase in the rate of inflation and that the nominal interest rate will rise by less than is predicted by the modified Fisher effect.

The reason will be a drop in the real rate induced by a negative shift on corporate loan demand that, in turn, is caused by the harmful effect of inflation on profits.

Finally, the excess taxes paid by corporations finance government expenditures and maybe viewed as another form of "inflation tax" that is added to other taxes collected by the government to finance its operations. A reduction on excess taxation of corporations, without a change in government budget expenditures, leads to an increase in the budget deficit, a reduction in planned expenditures, or an increase in other rates (e.g. an increase in the direct value of personal or corporate income taxes).

A recent estimate by the office of tax analysis in the US Treasury reported by Auerbach (1982) indicated that a proposal to correct corporate taxation by a method of accelerated depreciation may lead to a considerable loss in corporate taxes, to the extent that it will largely eliminate the corporate income tax as a source of government revenue.

2.2 Wealth Distribution Due to Unanticipated Inflation

The economic literature and more recently the finance and accounting literature have dealt with the potential wealth distribution due to unanticipated inflation. There are three hypotheses, that attempt to explain the redistribution of wealth, during periods of inflation.

(1) Inventory hypothesis

(2) Wage-lag hypothesis

(3) Debtor-creditor hypothesis

2.2.1 Inventory Hypothesis

This hypothesis states that business firms will gain during periods of unanticipated inflation because they carry inventories. Firms that have relatively more inventories will, therefore, gain more than others. Kessel (1956) rejected the inventory hypothesis and concluded that:

> "Clearly in real terms there is no gain or loss, no change in terms of trade of inventories for real resources, as a consequence of inflation for owners of inventories. Reported business profit may appear larger as a result of these gains. However this is purely an aircraft of original cost accounting. The unanticipated inflation has

the same impact on industry as it has on other real assets. The effect on real assets is captured by the debtor-creditor hypothesis, therefore the inventory hypothesis is less useful than the debtor-creditor hypothesis.

2.2.2 Wage-Lag Hypothesis

According to this hypothesis in periods of inflation the increase in wages will be lower than the increase in some general price index. The reasons given for this phenomenon are : existence of long-term wage contracts, lack of foresight by workers and weak bargaining power.

Given that the wage-lag hypothesis is valid, real wages will decline during periods of inflation. Therefore the workers will lose and the employers will gain. Because of the wage-lag, business firms will gain during periods of inflation. However the wage-lag hypothesis has had little empirical support. Kessel and Alchion (1959) found that wages did not lag the price level for any significant period and that any apparent lags could be explained better by changes in demand and supply conditions. A later study by Cargill (1969) came to the same conclusions.

2.2.3 Debtor-Creditor Hypothesis

This notion is based upon the hypothesis that debtors gain from inflation and the assumption that business firms are debtors, then wealth will be transferred from creditors to debtors firms if the creditors inflationary expectations are less than the actual rate of inflation.

Specifically it is assumed that, (according to the debtor-creditor hypothesis), at a given point in time all the units in the economy know the interest rates and have expectations about future price changes. According to those factors and other economic variables, each unit decides on the composition of its monetary assets, monetary liabilities and equity. The amount of monetary assets that each of those units is willing to hold, is directly related to interest rates that represent an opportunity cost of holding these assets and incorporates price level expectations.

Let us assume that after some time these units change their expectations about future price changes and their new expectations are higher than the previous ones. It is important to understand that inflation is actually a form of a tax on monetary assets, whose real value decreases approximately by the rate of inflation. Because of the new expectations about inflation, each of the units realises that the composition of its assets and liabilities may not be optimal. The result is an increase in demand for non-monetary assets and a decrease in demand for monetary assets. The new equilibrium will have high interest rates and higher values for non-monetary assets. Higher interest rates imply lower prices of debt securities. Net-debtors gain from this situation, because the present value of their debt is lower and their gain is equal if there is no change in the interest rates, net debtors will still gain (creditors will lose), because of the decreased purchasing power of the monetary payments, through time.

To illustrate the concept of debtor-creditor hypothesis, a simple example is presented. Let us assume three hypothetical firms with the following financial positions:

	Firm A	Firm B	Firm C
Monetary Assets	100	100	100
Real Assets	200	200	200
Monetary Liabilities	200	100	50
Stock Equity	100	200	250

To perform the computations, two assumptions are made :

(1) the unanticipated inflation was 10% (the anticipated 0%).

(2) there were no other changes in the position of the three firms.

Assuming no change in interest rates and in the anticipated rate of inflation the nominal increase in stock equity will correspond to the increase in the value of real assets 10%. Therefore the following changes incurred in stock equity.

	Firm A	Firm B	Firm C
Stock equity before the change	100	200	250
Stock equity after the change	120	220	270
Nominal return to shareholders	20%	10%	8%
Real return to stockholders	10%	0%	-2%

Firm A a net debtor (monetary liabilities monetary assets = 100) had a gain in real terms; Firm B neutral, was not affected; Firm C, a net creditor, suffered a loss.

The same calculations are repeated under the assumptions that the current rate and the expected rate of inflation both increase by equal amounts and result is a 10% decrease in the monetary assets and liabilities.

The new financial position

	Firm A	Firm B	Firm C
Monetary Assets	90	90	90
Real Assets	220	220	220
Monetary Liabilities	180	90	45
Stock Equity	130	220	265

Given the above information the change in stock equity is:

	Firm A	Firm B	Firm C
Stock equity before the change	100	200	250
Stock equity after the change	130	220	265
Nominal return to shareholders	30%	10%	6%
Real return to stockholders	20%	0%	-9%

The results indicate that an increase in interest rates (relative to no change) increases the real return to stockholders of net debtor firms and decreases the return to stockholders of net creditor firms, Therefore the effect of an increase in interest rates is positively related to the purchasing power effect and therefore enhances the redistribution of wealth in periods of unanticipated inflation.

The distinction between anticipated and unanticipated inflation is very important. Only an unanticipated inflation results in a gain to net debtors and a loss to net creditors. The presence of other economic effects may of course change the results.

Kessel (1956) was the first to perform a rigorous study of the debtor-creditor hypothesis. He observed the relative performance of companies during an inflationary period 1942-1948. For each of the companies Kessel computed the NDNCR (Net Debtor/Net Creditor Ratio) and the total return over the inflationary period. His first example included 16 Bank companies. All of the bank companies were net creditors. Kessel computed the correlation between the NDNCR and the total return over the inflationary period and obtained a rank correlation of 0.48 which is significant at the 5% significant level. NDNCR measuring the exposure to inflation and defined by Kessell as NDNCR (Monetary liabilities - monetary assets/total equity).

His next sample included 30 industrial companies, which were evenly divided between net debtors and net creditors. For this sample the shares of the 15 net debtors increased in real value by 81% where as the shares of the 15 net creditors declined in real value by 13% (during the same period the Standard and Poors index of 50 industrials declined by 5% in real terms). The correlation between the values of NDNCR and the rate of return was 0.47 (significant at 0.002). To confirm the results of the industrial companies, Kessel selected another sample of 20 firms. The results from the last sample confirmed the previous findings.

According to the debtor-creditor hypothesis firms gain (increase in the real value) during periods of unanticipated inflation and lose during periods of unanticipated deflation. Therefore, Kessel also studied the period from the end of December 1929 to the end of June 1933 in which the wholesale price index declined by about one third. The sample contained 12 net creditors and 19 net debtors.

In real terms the prices of net creditors increased by 6% while the prices of net debtors decreased by 34%. The correlation between the two series was -0.46 significant at the level of 0.005. Generally the results of Kessel's study, strongly support the debtor-creditor hypothesis.

Three years later Alchion and Kessel (1959) published an article in which they studied the net monetary positions of business firms and the relative performance of debtors versus creditors. This was a more comprehensive study of all industrial firms whose common stock was traded on the New York Stock Exchange at any time between 1914 and 1952. They incorporated in their study on new measure of net-monetary debtor or creditor status, the ratio of net-monetary debt to the market value of the firms common stock. They employed a t test for differences between the means of the relative market value of debtor and creditor firms, adjusted for stock splits and dividends and assumed that all cash dividends were continuously reinvested in the firm.

Although not all of the statistics are significant, the study generally presents strong support of the debtor creditor hypothesis as did the previous study by Kessel. Actually those are the only two studies which strongly support the debtor-creditor hypothesis.

Interestingly enough Bach and Ando (1957) performed almost identical tests on samples of firms drawn from about the same inflationary period (except that they broke it into three subperiods) but obtained rather different results. They performed rank correlation testing using net monetary debtor or creditor rank and the increase in stock prices over those three subperiods. Bach and Ando concluded:

"Debtor or creditor status was not a dominant factor in determining the inflation period gain or loss of corporations during the three inflations studied. Other forces, especially changes in sales volume, but perhaps other factors as well, such as the lead lag effects of various costs and prices apparently exercised more dominant effects, regulating debtor-creditor effects to a relatively minor role"

The main explanation for the divergence of their results from those of Alchion and Kessel was, that their samples were substantially different and were drawn from both the New York Stock Exchange and American Stock Exchange.

In a relatively recent study Bach and Stephenson (1974) tested the debtor-creditor hypothesis. Their results indicate that for two inflationary sub-periods 1955-1957 and 1965-1970, the ratio of the increase in stock value for net creditor firms divided by the increase in stock value for net debtor firms was more or less constant.
Weak debtor-creditor effects were present in some period (1955-57), but creditor firms actually performed slightly better in the 1965-70 inflationary period.

Bach and Stephenson introduced the effect of depreciating fixed assets at historical cost by subtracting the estimated tax loss due to understating depreciation from each firm's estimated debtor gain, and calling the results the firm's "net exposure" to inflation.

The exposure to erosion on net creditor account ENCA:

ENCA = (MA-ML)k where :

MA = monetary assets

ML = monetary liabilities

k = the actual rate of inflation

The exposure of depreciation account EDA :

EDA = Fx(t)k where :

Fx = Net fixed assets

t = the tax rate

k = the actual inflation

Net fixed assets times the tax rate is the future tax savings from future depreciation deductions. When multiplied by the rate of inflation, a measure of the erosion of future tax savings due to inflation can be developed.

Total exposure = ENCA + EDA

= (MA-ML)k + Fx(t)k

Bach and Stephenson define a positive exposure as one in which the firm's net creditor exposure is greater than its exposure on depreciation account. A negative exposure is one in which the net debtor exposure is greater than the exposure on depreciation account.

However, comparison of positive and negative exposure firms in this manner also failed to yield strong or consistent results. Possibly debtor-creditor effects were absent but one might have expected the depreciation effect to show up.

But the problem might have been, as Hong (1975) suggests, the computational procedures for determining positive and negative exposure firms.

The authors, however, suggested that the inflations might have been generally anticipated and that

> "Unless security analysts peer effectively through accounting reports to the real inflation effects, the effects on security prices may be delayed and security markets may be inefficient".

Reviewing the major empirical research on the debtor-creditor hypothesis, it is obvious that the empirical results are inconclusive. Only the studies of Alchion and Kessel (1959) and Kessel (1959) found a strong support for the hypothesis, the more recent studies found very little support.

2.3 Fisher-Effect Debate

The effect of inflation or nominal interest rates, which was discussed extensively by Irving Fisher (1930) has received renewed attention in the economic literature since the early 1970's. The coincidence of rising inflation rates, rising nominal interest rates and accelerating money growth that characterised much of the 1970's was difficult to explain, without reference to the Fisherian emphasis on the role of inflationary expectations in determining interest rates.

Without considering taxes, Fisher made it clear that if a unit change in inflationary expectations resulted in an equal unit change in nominal interest rates, it was possible to conclude that the expected real interest rate, a crucial determinant of investment and saving behaviour, would remain constant. In such a case, monetary changes that generated inflation and subsequent inflationary expectations could be judged "neutral" or have no effect on real economic activity or on relative prices. Empirical investigations in this area, like those of Gibson (1972), Carlson (1977), Joines (1977) and Nelson and Schwert (1977) often reported estimated impacts of expected inflation proxies on nominal rates significantly below unity, suggesting that higher anticipated inflation was associated with lower expected real rates.

Two explanations for this result were put forward by those who expected to see some form of the neutrality condition emerge as the "true" result. The first group cited measurement error in the proxy for expected inflation. Such measurement error could bias downward the estimated coefficient on anticipated inflation. Others, including Sargent (1972) and Levi and Makin (1978), pointed to the Mundell effect, whereby one would expect a rise in anticipated inflation to depress the expected real rate, thereby causing a less-than unitary impact of anticipated inflation on nominal interest.

The question as to possible non-neutral effects of anticipated inflation became evidently, when a number of authors began to point out, that after-tax real and nominal interest rates were what really affected economic behaviour (see Darby (1975), Felstein (1976) and Tanzi (1976)). In particular, it was shown that as an income tax is levied on nominal interest earnings, and if a rise in anticipated inflation is to leave constant the after-tax expected real interest rate, the nominal rate must rise by more than the rise in anticipated inflation.

The estimated impact had to be well above the value of unity indicated by the Fisherian no-tax analysis.

The role of taxes in empirical testing of the Fisher Hypothesis was first carried out in a general equilibrium framework by Levi and Makin (1978). They drew on the important earlier papers of Darby (1975), Feldstein (1976) and Tanzi (1976), which, as we have mentioned, they made explicit that, the behaviour of investors depends upon expected after-tax real rates. When this reality was combined with a general equilibrium framework that determined interest rates, as well as prices, output, and employment, Levi and Makin (1978) were able to demonstrate that, a coefficient of unity describing the impact of anticipated inflation, on nominal interest, was both plausible and reasonable in a world where taxes were considered.

Implications of the model that indicated a need for inclusion of additional explanatory variables included output, growth and inflation uncertainty. More recently, surprise money growth and unanticipated budget deficits have also been shown to enter significantly into interest rate equations by Makin (1982, 1983).

Nevertheless in general, most empirical studies have reported apparent under adjustment of nominal interest rates to changes in anticipated inflation, especially in the light of the impact of taxes on interest earnings.

To that effect, several explanations have been offered from various authors. For example, Feldstein and Summer (1978) suggested that the non adjustment of interest rates relates to the real effect of inflation of inventory and to depreciation that tends to result in overstatement of profits. Under such circumstances, inflation may reduce the firm's demand for loans by reducing their ability to repay, as well as their incentive to borrow money for investment projects. While the real cost of loans may decline with inflation, the real after-tax return from the use of a loan may also decline with inflation. The phenomenon may account for some apparent underadjustment of nominal interest rates to changes is anticipated inflation.

A further explanation for underadjustment of nominal interest rates to changes in anticipated inflation, suggested particularly by Tanzi (1980a, 1982b) and Summers (1981), is the existence of money or "fiscal illusion" in the market. This illusion is said to decline over time, as investors become accustomed to a change in the inflationary environment.

All the above considerations have been part of the rapid progress, made in theoretical and empirical analysis of interest rate behaviour. An important part of this progress, however, has given explicit recognition to the fact, that actions of economic agents are governed by after-tax interest rates.

2.4 The Fisher Effect For Risky Assets

There is a well documented empirical relation between stock returns and inflation. Expected inflation, unexpected inflation, and changes in expected inflation are all negatively related to stock returns. Lintner (1973), Oudet (1973), Bodie (1976), Jaffe and Mandelker (1977) and Nelson (1976) have all reported that common stocks in the USA have been poor hedges against inflation. Fama and Schuert (1977) compared the inflation hedge properties of common stock, with those of a number of financial and real assets, including human capital with results similar to those mentioned above. They found that common stocks are poor hedges, not only against unexpected inflation, but also against expected inflation. The latter finding is inconsistent with the Fisher hypothesis, which predicts a positive relation between expected nominal returns and expected inflation.

While expected stock returns and expected inflation in the US have been found to be negatively related, Firth (1979) showed that in the United Kingdom the results are just the opposite of those in the USA. However, international evidence from Solnic (1983) and Gultekin (1983) substantiate the negative reaction between nominal stocks returns and inflation rates.
The evidence so far therefore contrary to economic theory suggests that stock returns are negatively related to inflation. If we accept that this is the case, then we have to find some kind of explanation for this negative relationship.

Several explanations have been offered by different researchers. For example, Kessel (1956) as we mentioned earlier, pointed out that unanticipated inflation benefits net debtors at the expense of net creditors. This implies, that equity returns of only those firms which are net creditors would be negatively related to unexpected inflation, so that an aggregate negative relation for all stocks would require equity holders to be net creditors on average. But as Geske and Roll (1983) point out, "since most non-financial corporations appear to have more fixed nominal liability commitments than fixed nominal assets, they are net debtors and Kessel's argument is not empirically compelling".

Lintner (1975) has argued that :

(1) A company's relative dependence upon outside financing will necessarily be higher, the higher the rate of inflation, whether expected or unanticipated and,

(2) this greater relative dependence on outside financing required by an increase in realised inflation during any period, will necessarily reduce the value of outstanding equity and consequently also reduce the real rate of return realised on equities during the period.

Both of these results Lintner believes hold whether new equity or added debt is issued to meet the added financing required to maintain real values of growth in the face of either an unexpected inflation or higher rate of fully anticipated inflation. The theory consequently explains the negative relations of both real and nominal returns on equities with levels of inflation whether anticipated or unanticipated, which has been observed in empirical work.

In order to prove the first hypothesis Lintner considers the effects of uniform proportionate changes in all prices upon a firm which maintains a fully synchronised steady-state rate of growth in real terms.

Furthermore he assumes that (1) capital stock and current rates of real investment are proportional to physical output at all times, (2) depreciation is also proportional to capital stock and is taken at replacement cost for tax purposes, (3) corporate profits are taxed at a fixed percentage rate, (4) dividends are a fixed fraction of profits after tax and, (5) prices at all times provide a fixed percentage margin of gross operating profit over inventories valued at replacement costs, and the dollar amount of overheads, selling and all other costs are proportional to dollar sales.

From the above assumptions, the excess of current dollar outlays for fixed investment over gross funds retained from operations (retained earnings plus depreciation) can be seen as a fraction of current dollar sales and is symbolised by bSt where b is invariant to rates of inflation.

Now, from the accounting statement of "sources and uses of funds" we can see that additional external funds will be required to cover increases in cash balances and accounts receivable inventories. Lintner further assumes that (1) cash balances bear a fixed ratio to current dollar sales, (2) a fixed fraction of sales are made on credit, (3) there is a fixed collection period on receivables, (4) no interest income on cash and, (5) receivables are not adjusted for changes in the rate of inflation.

The above assumptions, according to Linter, justify additional demands for external funds, $\alpha \Delta S_t$, which is equal to a fixed fraction of the increases in current dollar sales, where α is necessarily positive and also invariant to rates of inflation.

Therefore, total demand for external funds required to maintain real growth rates under these conditions is given by :

$$\Delta F_t = \alpha \Delta S_t + bS_t$$

Since under the above assumptions both retained earnings and gross retained funds are respectively proportional to S_t, the ratio of external to internal financing will increase with inflation rates if $\Delta F_t/S_t$ does so. But the latter is a linear increasing function of $\Delta S_t/S_t$ which in turn is an increasing function of inflation rates. Consequently the relative dependence on external financing, necessarily varies directly with realised inflation rates.

For the second hypothesis, Lintner believes this is because the outside financing involves a "deadweight dilution" of the real returns on owning equities over the period. If the added financing required to maintain real rates of growth is obtained by added debt, the after tax cost of the debt not otherwise required will directly reduce real returns to equity owners, even though the company's real profits are maintained.

Alternatively if the added financing is obtained with new equity issues, even if the new issue price is initially the same, the owners of the previously outstanding shares end up owning a smaller fraction of the company's total equity, and, their real return will have been impaired even though the company's real returns have been fully maintained. The point to note here is that the dead weight real financing costs involved are in addition to any negative impacts of an increase in interest rates.

Criticism has however come again from Geske and Roll (1983) who say that "it seems rather implausible that managers are so obstinate or inflexible that they obtain external funds and invest them in subpar assets. To the contrary, corporate treasurers respond rather aggressively to increased inflation by cutting cash balances, tightening the terms of trade credit, delaying payments and by numerous other devices detailed in working capital management textbooks and corporate handbooks. Thus Linter's theory also seems unlikely to explain the phenomena under study".

Modigliani and Cohn (1979) believe that investors are unable to free themselves from "money illusion" and that as a result, they price equities in a way, that fails to reflect their true economic value.

Geske and Roll (1983) argue that M-C argument conflicts directly with rational expectations and market efficiency and suffers the typical defect of a theory, based on irrationality and concocted after the data are observed.

Lewellen (1979) believes that M-C overlooked an important element in the analysis "that element relates to the distinction they draw between "conventional" and true profits" where only the latter captures the gain to shareholders arising from the decline in the real value of the claims of creditors.

A moments reflection reveals that, what they describe as "true" profit is most unlikely to be unappreciated by investors - since it is in fact the actual cash flow received as dividends by corporate shareholders under inflation. Consequently the stock prices we see should not suffer from the illusion Modigliani and Cohn allege, and we must look elsewhere for possible explanation of any potential valuation "errors".

Fama (1981) in an attempt to explain the negative relationship between a stock returns and inflation, he argues, that it is due (a) to negative relation between inflation and real activity which in turn is the result of policies of controlling inflation (i.e. demand managements Keynisian approach, supply of money monetarists approach) or a combination of both of them, and (b) the positive relation between real activity and stock returns.

In order to test whether there exists a negative relationship between real activity and inflation he regressed the inflation rate for period t with the growth rate for the base for period t, and the growth rate of industrial production (real activity) using monthly, quarterly and annually time series data.

His findings showed that relationships between the inflation rate and the real activity are negatively significant. Therefore as expected an increase in inflation produces a decrease in real activity.

Fama's next step was to run regressions between real common stock and the real variables from the capital investment process. His results show a strong positive relation between real returns and the independent variables.

Having established that measures of inflation and expected inflation are strongly related to future real activity, and that real stock returns are also strongly related to future real activity, he attempts to test whether the stock return inflation relations observed, during the post 1953 period proxy for more fundamental relations between stock returns and real activity.

With the use of about 23 regression equations Fama suggests that current and past real activity are always important, especially in inflation regressions, but never have marginal explanatory approach power in the stock return regressions. Base growth rates are at least as important as future real activity growth rates in the inflation regressions, but future real activity growth rates demonstrate base growth rates in the stock return regressions. All of this suggests, that expected inflation rates enter stock return regressions primarily because they happen to be functions of future activity growth rates, which are of more direct concern to the stock market.

On the other hand Roll and Geske (1983) argue that stock returns are negatively related in expected inflation, because they signal a chain of events which results in a higher rate of monetary expansion.

Exogenous shocks in real output signaled by the stock market, induce changes in tax revenue, in the deficit, in Treasury borrowing and in Federal Reserve "monetiration" of the increase debt. Rational bond and stock market investors realise this will happen, and therefore adjust prices (interest rates) accordingly. Therefore stock market returns signal changes in the inflationary process. This is because of the following changes of macroeconomic events. Changes in the stock market returns lead to changes in government revenue and of government expenditure do not accommodate for these changes in revenue, this will be reflected to changes in deficits. But when a deficit is occurred government has to borrow. This borrowing can be repaid by increasing direct taxation or reducing expenditure and therefore creating a surplus in later years, or as the norm is to increase the monetary growth and through the indirect taxation caused by inflation find the required surplus. Therefore, when stock prices decline governments run deficits. However, given the practice of monetiration (which will be anticipated by rational citizens) expected inflation will rise.

Hence stock market price changes which are caused by changes in anticipated economic conditions will be negatively correlated with changes in expected inflation.

It is also accepted that changes in the expected inflation, cause a more than proportional change in the immediate actual inflation rate, and the "Friedman surge" follows in actual inflation, as citizens alter real money balances, in response to altered inflationary expectations. This implies that stock market price changes will be negatively correlated with unanticipated actual inflation.

As far as the demand for money is concerned as an explanation for the negative relationship between inflation and common stock, (Fama 1981), Roll does not deny that the demand of money can create such a relationship, but at the same time he believes that the supply of money can create such an effect and he goes on to say that it is highly improbable that anyone will be able to identify precisely the relative importance of demand and supply.

Having outlined their argument Geske and Roll have tried to provide empirical evidence that each element in the proposed chain of events actually occurs and they conclude that

> "with data from the past three decades, we have examined every link in the causative chain described above and have found supporting evidence in each case. The fiscal and monetary linkage from stock returns to money base growth is firmly in place. Thus stock returns signal change in nominal interest rate and changes in expected inflation".

2.5 Conclusion

This chapter has dealt with a number of issues of inflation, in an attempt to improve our understanding of the environment under which business firms operate.

In particular, attention was focused, in the first part of the chapter, on the real effect taxes have on firms in an inflationary economy, as a result of a tax system, that is not fully indexed for inflation.

The latter sections have presented evidence on the effect of inflation on interest rates and the negative impact it has to the prices of common stock. Specifically it was shown that the above relations are achieved only when the effect of inflation on other macroeconomic variables is examined and their interrelationship is understood. In the next chapters the effects of inflation on investment is analysed.

CHAPTER III

THEORIES OF AGGREGATE INVESTMENT

Fixed investment in the private sector is considered to be the most important component of aggregate private expenditure in the determination of national output, despite the fact that consumers expenditure constitutes a much higher share of G.D.P. This is so mainly because consumer's expenditure is a relatively more stable percentage of G.D.P. than investment which fluctuates and which in fact explains the business cycles. Furthermore the importance of the degree of fixed capital expansion derives also from the fact that it is through positive net investment that the productive capacity of the economy can expand in the long-run. Similarly at firm level fixed capital formation is an important element in the survival and growth of the company.

Therefore, it is not surprising why governments are using tax incentives as a means for stimulating investment. However, the effects of such incentives are not easily observable. Many controversies amongst economists still exist as to the precise nature of the determinants of investment. For instance, many keynesians believe that the interest elasticity of the investment function is small because the function is dominated by uncertain future cash flows, while economists in the classical tradition believe that investment is sensitive to interest rates. These controversies extend to the impact of fiscal investment incentives. If investment is not sensitive to interest rates, the ability of monetary policy to affect investment through interest rates is restricted. Leaving aside these controversies, even among the classicals the effect of fiscal policy on investment behaviour is an issue of considerable controversy.

Accordingly economic models have been occupying a central role in untangling many factors which influence the capital expenditure. However, there is no single accepted description of the investment behaviour which clearly dominates the competition. There are several review articles on comparing of alternative models of investment behaviour where different theories are exhaustively reviewed, explained, and their empirical performance compared (see, for example, Jorgenson and Siebert (1968), Jorgenson et-al, (1970), Kopcke (1977) and Clark (1979)).

Therefore because of the abundance of such review articles, and because of the focus of this study only a short review of the non-neoclassical models is presented, while the neoclassical approach is described in detail.

3.1 Generalized Accelerator Model

Models of the accelerator type relating investment in fixed capital to changes in output have their origins in work done by J M Clark (1917) early in this Century and later modifications by Koyk (1954) and Chenery (1952). In its most elementary form the accelerator model relates the desired capital stock (K_t^*) to output (Q_t) by

$$K_t^* = \alpha Qt \tag{3.1}$$

where a is a constant. The distinguishing feature of the accelerator model is that the determination of the planned capital stock is based only on output and not on such factors as the cost of capital, the price of investment goods and various features of the tax system. In other words, technological constraints mandate that the firms stock of capital must vary directly with the level of output. Implicit in the formulation of (3.1) is the assumption of putty-clay technology with capital output ratio invariant over time.

This elementary statement of the accelerating principal has been strongly challenged over the years on the basis of the empirical observation that capital stock does not show the same wild swings of the output over time. Accordingly the model has evolved into a more general statement. To explain the slow reaction of capital stock to output "flexibility" is added to the model by a partial adjustment process of the type

$$K_t - K_{t-1} = b\,(K_t^* - K_{t-1}) \qquad (3.2)$$

Where actual stock of capital (K_t) adjusts towards its desired level (K_t^*) by a constant proportion of the difference between desired capital this period and the actual stock of last period and (b) is the speed of adjustment.

The reaction of the actual stock of capital (K_t) to output is spread over a number of time periods through a set of distributed lag coefficients (bs).

$$I_t^N = K_t - K_{t-1}$$

$$= \sum_{s=0}^{\infty} bS(K_{t-s}^* - K_{t-1-s}) \qquad (3.3)$$

Where I^N is the net investment.

Equation (3.3) implies that only a fraction of desired change in the stock of capital is translated into investment in each period.

The discussion so far has focused on net additions to the capital stock, and has ignored replacement investment.

If it can be assumed the depreciation is approximately exponential and that the replacement of depreciated capital responds linearly to current and lagged output, then gross investment, I_t, can by represented as a distributed lag on output, plus a constant (d) (the rate of physical depreciation) multiplied by the capital stock of the last period.(1)

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(1) It has been correctly argued that replacement investment is not likely to follow automatically the depreciation of old capital. See, for example M S Feldstein and D K Foot (1971). Nevertheless equation (3.4) may still be a reasonable representation of gross investment if a higher capital stock implies higher replacement expenditure for some types of capital.

$$I_t = a \sum_{s=0}^{\infty} bs\,(Q_t - Q_{t-s}) + dK_{t-1} \qquad (3.4)$$

The usual theoretical discussion of the flexible accelerator ends at this point, having either implicitly or explicitly assumed that expectations about future levels of output are static, expected future output is equal to its current level. Such an assumption is clearly unwarranted at a theoretical level; firms expect future output to move in a number of ways and play long-range production strategy ten or more years in advance. If expectations about future output are not static, then investment in time period (t) should be a function of all the expected future levels of output and any other past variables that are important in forming expectations of future output.(2)

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(2) For a discussion of some of the problems in specifying the lag structure in a simple model of this sort, see Marc Nerlove (1979). Such theoretical considerations have not yet proved fruitful in many empirical applications.

In general the modern interpretation of the accelerator model assumes that past levels of output are the most important determinants of expectations about future output, and that other variables that might have been included in the model either have little impact on expectations or are observed with such large errors that they are best omitted altogether in empirical work.

Although few economists would consider them complete representations of the investment process, models of this sort have been tested against a great variety of data and they have generally performed well. Many forecasters use this model as at least one element in their predictive equations, but they usually modify it by adding other variables, including interest rates, cash flows, and variables designed to incorporate the effects of tax policies.

3.2 Accelerator - Cash Flow Model

Modifications to the general accelerator model include the rate of expectations and profit maximization. Two alternative rationalizations of this profit oriented accelerator model have been offered. First, Tinbergen (1939) argues that realised profits measure expected profits and that "it is almost tautology to say that investment is governed by profit expectations". Secondly the rate of investment may be constrained by the availability of funds. Jorgenson and Siebert (1968).

However it has been argued that realised profits do not necessarily measure expected profits and that "even the assertion that expected profits govern investment is far from being a tautology" (Grunfeld 1966 p. 215). He suggests that the profits variable probably plays the role of a surrogate in that it tends to be correlated with some of the main forces impacting upon investment.

In attempting to justify theoretically the addition of a profits term to an accelerator investment equation two broad points arise. First, changes in profits should convey some information about the future profitability of the firm and the requisite level of capital stock. Secondly, internal funds could be less costly than external finance if the market for borrowed funds is imperfect. Larger amounts of internal funds available might thereby lower financing costs and increase investment demand (Clark, 1979, p. 81).

A very critical assumption that has generated other alterations to the general accelerator model is that prior to an increase in output, firms must not have excess capacity. Since excess capacity is frequently observed in reality, attempts have been made to alter the accelerator model to fit these facts. Strong empirical results from work performed by Kuh (1963 (b)), Eisner (1962, 1963, 1967) and Hickman (1965) support the flexibility associated with the incorporation of capacity utilization. Jorgenson and Siebert (1968) Eisner (1967) concluded that a prime determinant of capital expenditure is the relation between expected future demand and existing capacity. If any expected increased future demand can be met by existing excess capacity, then new investment spending will not likely be incurred; on the other hand, if the expected increased demand can not be met with any existing excess capacity the new investment would be necessary (Eisner (1967) p. 364).

To summarize the accelerator approach has given birth to two additional theories, and there exist three distinct theories of investment based upon this approach; the original theory based on changes in output, a capacity utilization theory, and a profit oriented approach.

3.3 Securities Value ('q') Model

The securities value model attempts to explain investment on a financial basis. Roughly speaking if the market value of the firm is greater than the replacement cost of its assets, it can increase its market value by investing in more fixed capital. Conversely, if the market value of the firm is less than the replacement cost of its assets, it can increase the values of shareholders equity by disinvesting some of its stock of capital.

Theoretical models emphasizing the relationship between investment and the ratio of market-value to replacement cost ('q' ratio) have been proposed by a number of authors particularly Tobin and Brainard (1968, 1977). These models are basically a restatement of the neoclassical theory of corporate investment which is based on the assumptions that management seeks to maximize the present net worth of the outstanding shares. The point of departure for securities value models is that in deciding on desirability of an investment project we should look at the stock markets appraisal of the investment project. The securities market appraises the project, its expected contribution to the future earnings of the firm and its risks. If the value of the project as appraised by the market exceeds the cost, then the firms stock price appreciates to the benefit of shareholders.

Clearly it is the 'q' ratio on the margin that matters for investment, the ratio of the increment of market value to the cost of associated investment. The crucial value for marginal 'q' has been considered to be 1, although it is recognised that the average 'q' could be different (for a detailed explanation of the reasons for average 'q' being different from 1 see Lindberg and Ross (1981). Tobin and Brainard (1977, p. 238) write :

> "Economic logic indicates that a normal equilibrium value for 'q' is 1 for reproductive assets which are in fact being reproduced, and less than 1 for others. Values of 'q' above 2 should stimulate investment, in excess of requirements for replacement and normal growth, and values 'q' below 1 discourage investment".

In empirical implementation of the 'q' theory researchers face the problem that only average 'q' could be observed from available data while it is marginal 'q' that really matters for investment decision Tobin and Brainard (1977) write :

> ".....the forces of continuity in the economy are strong. Especially for short term variations of aggregate demand, we can expect that the same factors that raise or lower 'q' average" on the margin raise or lower 'q' average".

thereby justifying the use of average 'q' to study investment behaviour.

The empirical specification of the security value model is

$$I_t = a + \sum_{s=0}^{\infty} m_s \; q_{t-s} \qquad (3.5)$$

There are however a number of problems in implementation of the securities value model. First there exist a number of different ways of computing the market value of the firm and the replacement cost of capital stock. Second when taxes are taken into account the equilibrium value of 'q' need not necessarily be unity as it may depend on which method of finance used to finance the marginal project also on the assumption as to the role of dividends. These specifications have led previous studies to find a variety of values of 'q ' using the same data. Third even if we were to observe the marginal 'q' we would only be able to say whether the firm must invest or not. In other words the 'q' ratio indicates the direction of the investment and can not explain the magnitude of the investment needed to equate the marginal 'q' ratio to one. Fourth since all policy and exogenous variables show their impact, implicitly through observed 'q' values, the model can not be used for any policy analysis applications.

However, despite these reservations as to the validity of the valuation ratio, empirical studies performed in U.K. by Jenkinson (1981) and Oulton (1981) have found it to fit the aggregate data quite well.

3.4 Neoclassical Model

The investment models reviewed so far lack a feature that most economists consider crucial: namely, that investment depends on the price of capital. Jorgenson and a number of colleagues (Jorgenson (1967), Jorgenson and Stephenson (1969), Hall and Jorgenson (1971)) have attempted to remedy this objection by developing a model based on the theoretical framework in the work done by Arrow (1968, 1964) on optimal capital accumulation.

Whereas, for example, the accelerator model becomes a complete theory of investment behaviour by proposing that the prospective return to capital essentially depends on size of the capital stock relative to output, the neoclassical model admits the possibility that the demand for plant and equipment depends on more than that quantity of sales. The neoclassical theory assumes that, in the long-run, firms do not try to achieve a fixed ratio between levels of output and their stock of capital. Instead of varying the mix of capital and other factors of production, optimal capital-output ratio can be expected to vary with prices, interest rates, and the tax structure. Specifically each firm selects a production plan to maximise its net present value, defined to be the sum of discounted future revenues less future outlays, including taxes.

In order to obtain a complete description of the investment behaviour, it is necessary to specify the firms production function relating the flow of output to the flow of factor inputs including the flow of capital services. Then, in the context of the production technology, the firm determines its optimal investment program based on its forecasts of the demands for its output, relative prices, and the tax laws. To formalize the argument we adopt the work of Hall and Jorgenson (1967, 1971).

This model assumes that the objective of the firm is to maximize profit, defined as the difference between current revenue and outlay minus the rental rate (user cost) of capital services. The definition of profit may be represented in the following manner:

$$\Pi = PY - WL - CK \tag{3.6}$$

Where P = price of output

Y = output

W = price of labour input (wage)

L = quantity of labour input

K = quantity of capital input

C = user cost of capital

Profit is maximized at each point in time subject to constraint of given production technology

$$Y = \Phi\ (K,L) \tag{3.7}$$

The necessary conditions of profit maximization require that the marginal product of each input equal the price of that input. For capital this condition may be stated as:

$$\frac{d\Phi}{dK} = \frac{C}{P} = C^* \qquad (3.8)$$

Firms employ additional units of capital until the marginal product of the last unit equals the price of that unit of capital. The right-hand side of expression (3.8) is equivalent to the user cost of capital described in (4.16) in the next chapter but without adjustment for inflation. Any change in the implicit determinants of the user cost of capital, such as tax laws, the rate of interest, will cause firms to alter the stock of capital employed at any point in time. An increase in the user cost generates a net reduction in the optimal capital stock held by firms, while a decrease in the user cost has the opposite effect.

Investment represents the process by which firms adjust the optimal stock of capital. If the user cost of capital does not change in a given period, we would not expect firms to make any adjustment in the optimal capital stock. However, because the stock of capital deteriorates physically during production, firms attempting to maintain the current stock of capital will purchase goods simply to replace the capital used up during production. Gross investment in any period, therefore, is determined by the sum of replacement investment and any net additions to or subtractions from the optimal capital stock motivated by changes in the user cost of capital. Under the assumption that replacement investment is proportional to the actual capital stock, gross investment in any period equals

$$I_t^G = \Delta K_t^* + dK_{t-1} \qquad (3.9)$$

where I_t^G = gross investment in period t

ΔK_t^* = change in optimal capital stock

d = rate of economic depreciation

K_{t-1} = actual capital stock in period t-1

Empirical implementation of this model requires specific assumptions on the nature of production technology. In almost all studies of investment demand based on the neoclassical model of firm behaviour, the authors have assumed a Cobb-Douglas production function:

$$Y = \Phi\ (K,L) = K^a L^b \qquad (3.10)$$

where a and b are the elasticities of output with respect to capital and labour, respectively.

Before going any further it is worthwhile to highlight a few assumptions, implicit or explicit, in the formulation of the model.

These are :

(1) Output price is determined in a competitive market exogenous to model.

(2) Investment is reversible in the sense that the capital stock in excess of the desired level could be sold in perfect secondary markets at the prevailing price of capital goods.

(3) The stock capital is "malleable" ex post and ex ante. This is, not only the new equipment ordered embeds the technology which minimizes production costs at the prevailing relative prices, the capital-output ratio of the equipment carried over from the previous period could also be changed to minimize production costs.

(4) The uncertainty surrounding future prices and market conditions are essentially dismissed.

(5) Cost of capital (discount rate) is assumed constant and unaffected by the market conditions or the firms financial conditions.

(6) The flow of capital services is assumed to be proportional to the stock of capital.

With the specification of production technology in (3.10), the necessary conditions of profit maximization lead to the following result for capital input:

$$\frac{d\Phi}{dk} = \frac{ay}{k^*} = \frac{C}{P} = C^* \qquad (3.11)$$

This profit maximization condition is then easily manipulated to obtain an expression for the optimal capital stock for the current period:

$$K^* = \frac{ay}{C^*} \qquad (3.12)$$

The optimal capital stock in any period is determined by the relative magnitudes of output and the user cost of capital C*. Essentially, this expression states that the firm will employ additional units of capital until the value of the total capital stock equals the discounted value of the output produced with this capital.

A stochastic model of investment demand may then be specified as follows:

$$I_t^G = \beta_0 + \gamma_0 \, \Delta(K_t^*) + dK_{t-1} + V_t$$

$$= \beta_0 + \gamma_0 \, \Delta \left[\frac{ay}{C^*} \right]_t + dK_{t-1} + V_t \qquad (3.13)$$

where β_0 = constant term in regression

Y_t = stochastic disturbance term

The econometric specification may be further refined by incorporating lagged adjustment in investment due to the time required to order, produce, and install new capital once firms have recognised the need to change the optimal capital stock. Jorgenson and others have incorporated the notion of lagged response by specifying investment demand equations which include Polynomial distributed lag functions as follows :

$$I_t^G = \beta_0 + \sum_{j=0}^{n} \gamma_j \left[\Delta \frac{ay}{C^*} \right]_{t-j} + dK_{t-1} + V_t \qquad (3.14)$$

This econometric specification of investment demand may be interpreted as follows : actual investment expenditure in period t is determined by the sum of replacement investment and net additions to the capital stock purchased in the current period as a result of changes in the optimal capital stock in the current and previous periods. Desired changes in the optimal capital stock are brought about by the joint effect of changes in output and the user cost of capital in the current and previous periods. Gross investment in period t, therefore, represents the current period response of firms for changes in the determinants of desired capital which occurs over time.

The most difficult element in applying this model of investment demand involves specification and construction of the user cost of capital variable C*. To construct this variable Jorgenson and others have employed the definition of user cost of capital (see chapter IV) but without adjustment for inflation. This expression for the user cost of capital, including all relevant tax and non-tax factors and the requirement that depreciating capital be valued at historic cost, is

$$C^* = \frac{P_K}{P_Y} \frac{(r + d)}{1 - T} (1- T.Z) \qquad (3.15)$$

Where

P_k = the market price of capital (current prices)

P_Y = the market price of output (current prices)

d = the rate of economic depreciation

r = the rate of return

T = corporation tax

Z = present value of future allowances

By collecting time series data on interest rates, tax service lives, asset market prices, and economic depreciation rates it is possible to construct measures of the user cost of capital for different classes of assets.

Analysis of the historical investment behaviour of firms using this model has proven very successful. In several articles Jorgenson has demonstrated consistently that the constructed measure of the optimal capital stock, determined by the relative magnitudes of output and opportunity (user) cost of capital, is a significant variable in the determination of aggregate investment.

3.4.1 Lags and Investment Behaviour

Adjustment of the actual capital stock to a new optimal level is captured by a lagged process, representing the time required to plan, initiate, and complete new investment projects. This lagged adjustment process occurs in expansionary as well as replacement investment projects, although the lengths of such lags are not always equal. A brief statement of the assumed lag adjustment process used by Jorgenson seems useful at this point. [3]

Let the proportion of net investment completed in period t be μ_t. The distribution of such completions over time given a sequence of changes in the optimal capital stock may be represented by :

$$\mu_0, \quad \mu_1, \quad \mu_2, \ldots.$$

Where $\mu_t > 0 \quad t=1,\ldots N$ periods

Assuming the adjustment to the capital stock is completed then

$$\sum_{t=0}^{N} \mu_t = 1 \qquad (3.16)$$

The equation in net investment may, therefore, be defined as

$$I^N = [I_t - dK_{t-1}] \qquad (3.17)$$

$$\mu(S) \; [\Delta K^*]_t$$

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(3) Discussion of the rational polynomial lag in this section is based on Jorgenson (1966). See also, Wallis, K (1980).

Where S represents a lag operator specifying the sequence of lagged changes in the optimal capital stock in periods t_s, t_{s-1}, ..., etc.

Following Jorgenson (1963), the sequence of coefficients (μ_t) is represented by rational polynomial lag functions. With this assumption, a distributed lag function on changes in the optimal capital stock may be written as:

$$[I_t - dK_{t-1}] = \frac{v(s)}{w(s)} [\Delta K^*]_t \qquad (3.18)$$

where v(s) and w(s) are polynomials in the lag operator of degree S. Multiplying both sides of expression (2.18) by w(s), a specification of the net investment equation becomes:

$$w(s) [I_t - dK_{t-1}] = v(s) [\Delta K^*]_t \qquad (3.19)$$

Expanding the lag operators w(s) and v(s)

$$[1 + W_1 s + ... W_n S^n] [I_t - dK_{t-1}]$$

$$= [v_0 + v_1 S + ...+ V_n S^n] [\Delta K^*]_t$$

or

$$[I_t - dK_{t-1}] + W_1[I_{t-1} - dK_{t-2}] + \ldots + W_n [I_{t-n} - dK_{t-n-1}]$$

$$= V_o [\Delta K^*]_t + v_1[\Delta K^*]_{t-1} + \ldots + V_n[\Delta K^*]_{t-n} \quad (3.20)$$

From expression (3.20), the final form of the estimating equation may be derived. To this equation a stochastic error term (ε_t) is appended which is assumed to be independently and identically distributed over time.

$$I_t = V(s) [\Delta K^*]_t + [1-w(s)] [I_t - dK_{t-1}] + dK_{t-1} + \varepsilon_t \quad (3.21)$$

Remembering that $K^* = \dfrac{AY}{C^*}$, then

$$I_t = av(S_n) \left[\frac{Y_t}{C_t} - \frac{Y_{t-1}}{C_{t-1}} \right] + [1-W(S_n)]$$

$$[I_t - dK_{t-1}] + dK_{t-1} + \varepsilon_t \quad (3.22)$$

This equation states that the current period gross investment is determined by completions of investment projects executed to expand and/or replace the optimal capital stock. Both net and replacement investment are assumed to follow lagged adjustment processes, and gross investment represents the sum of current period completion of both types of investment. Note that the lagged adjustment process is not required to be the same.

The parameters v(s) and w(s) are unknown and must be estimated. This may be accomplished by applying ordinary least squares to expression (3.22) after prior selection of the lag lengths for the right-hand side variables.

3.4.2 Major Issues in the Neoclassical Model

The most criticised assumption is the reliance of the Jorgenson framework on the Cobb-Douglas production function. In a two-factor situation the Cobb-Douglas production function implies a constant and unitary elasticity of substitution; a given proportionate change in relative factor prices will always cause a profit maximizing firm to make an equivalent but opposite proportionate change in the factor inputs used to produce given output. Eisner and Nadiri (1968) have noted that Hall and Jorgenson have imposed rather than estimated the long-run effect of tax policy because they did not estimate the sensitivity of the firm's desired capital stocks to changes in factor prices. In order to overcome this problem, many economists have used the constant elasticity of substitution (CES) production function where the elasticity of substitution is estimated rather than imposed.

For two factors of production, capital and labour, constant return to scale and a suitable-choice of a unit of measurement for output, the CES production function may be written as :

$$Q = [aK^{\sigma-1/\sigma} + (1-a)L^{\sigma-1/\sigma}]^{\sigma/\sigma-1} \qquad (3.23)$$

where L represents labour input, a is constant and σ is the elasticity of substitution. When differentiated partially with respect to capital and equating the derivative to C/P and solving for K, we have:

$$K^{*} = \alpha^{\sigma}\left[\frac{P}{C}\right]^{\sigma} Q \qquad (3.24)$$

However the adoption of this production function and thus the estimation of the critical parameter has led to a number of different and controversial results. Eisner and Nadiri (1968) and Coen (1969, 1971) obtained estimates of σ tending to zero, thus reducing the neoclassical model into the general accelerator model. On the other hand, Boatwright and Eaton (1972) estimated σ to be between .4 and .7 and Feldstein and Flemming (1971) found σ to be between .28 and .5.

The most important contribution of the adoption of the CES production function is the fact that it allows to estimate separately the elasticities of the desired capital in relation to its different components. Bischoff (1971) adopting a putty-clay [4] description of factor malleability found that changes in prices (P/C) affect investment more slowly than changes in output.

Feldstein and Flemming (1971) by using the CES production function found it possible to estimate also the elasticities of the different components of the user-cost of capital and found for instance that the allowances affect significantly the level of desired capital.

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(4) A putty-clay model of production is one in which factor proportions are variable ex-ante before capital has been committed to a particular form of production and becomes 'clay'. A putty-putty model is one which assumes equal ease of factor substitution, both ex-ante and ex-post. A clay-clay model is one in which the producer has no choice of factor proportion within the constraints of known technology.

However, more recently Feldstein (1982) tested the model using U.S. investment and found that the model performs better by using the Cobb-Douglas production function than any other alternative. On the other hand Jenkinson (1981) found a preferred alternative value of 0.25, while Savage (1977), Bean (1981) and Bosworth (1984) adopted a value of half on practical grounds.

Following the assumption of perfect competition in the capital markets, Jorgenson in his framework did not consider any influence of profits or liquidity on the investment behaviour because there is no choice between borrowing and lending funds since both costs are the same. However in reality the two cases are different, and for a number of reasons the firm may be better off by using internal funds, as for instance they are less costly than external finance because of the differences in information about riskiness of investment. Profits or cash flows are considered to provide a better explanation of investment than direct demand proxies, because in addition to their obvious correlation with current demand levels, they also include important information about the current profitability of internal funds, which is, for some, a vital factor in determining the level of investment. A number of studies, thus, have employed some measure of profits or of the availability of internal funds as a possible determinant of investment, for example, Kuh (1963), Grunfield (1960).

Jorgenson (1971) noted that :

> "... where internal finance variables appear as significant determinants of desired capital, they represent the level of output. Where both output and cash flow are included as possible determinants, only one is significant determinant. The majority of evidence clearly favours output over cash-flow".

Mayer and Glauber (1964), on the other hand, developed the 'Accelerator - Residual Funds' theory where they showed that the availability of internal funds is significant determinant of the investment expenditure only in the decline or recessions periods, while in period of growth investment is determined mainly by output considerations and finance rarely constrains investment.

Agarwala and Goodson (1969) used as independent variable a measure of cash flow deflated by the price of investment goods, and on expected rate of return variable, and it was through these that the "liquidity" and profitability aspects of incentives separately operated. They found both these variables to be significant in an annual analysis spanning 1958-1966 and simulations indicated some considerable total effect. However Feldstein and Flemming (1971) could not give any economic interpretation to these results and commented that :

> "... a change in the rate of return would have the same absolute effect on investment regardless of the scale of output... and the cash flow variable is the only one that reflects the scale of the economy; it would therefore have a positive coefficient even if internal availability of funds as such had no economic effect".

Moreover, Feldstein and Flemming (1971) did not find any significance for the ratio of retained earnings and depreciation to trend output included in the cost of capital with its own separate elasticity and this is part of the measurement of the desired capital. This implies that the long-run effects of this variable are negligible. Further evidence is provided by Eisner (1967) when he finds that firms tend to make higher capital expenditures in the periods following higher profits, but that over the long-run firms earning higher profits do not make markedly greater capital expenditures than firms earning lower profits.

Nickell (1978) sees two problems arising from the use of the cash flow variable as a separate regressor :

> "First, it will signally fail to capture the notion that internal funds are only significant in relation to desired expansion. If the firm does not wish to expand because of a poor demand outlook for example, the availability of internal funds can hardly be relevant to its investment decision. Simple inclusion of a flow of funds variable will thus produce a rather patchy showing which will be exacerbated by the second problem, that of the well known collinearity of such variables with those of the accelerator type."

However, if the availability of internal finance does not determine the desired capital or cannot be used as a separate regressor, it might enter a properly specified investment function either as a determinant of the speed of adjustment of desired to actual or as a determinant of the cost of capital.

The first role has been examined by Coen (1969, 1971) and Prior (1976) by incorporating the flow of funds relative to desired expansions into the adjustment cost mechanism. Coen's results showed that if the cash flow available for expansion in the current period is small relative to the gap between desired and actual capital stock, then only about 10-12% of this gap is closed in quarter one, whereas between 28% and 33% of the gap is closed if the quantity of cash flow is equal to this gap. He concludes that the assumption of cost of capital is not valid.

Another important issue of the Jorgenson framework is that he adopts the assumptions of static expectations with regard to the levels of the relevant variables - output, prices, and costs. In reality the desired capital stock should depend upon expected future output expectations of the future production function and current and expected future prices, and if there is no perfect competition in the market, desired capital stock should depend upon production functions and supply and demand functions for inputs and outputs, as seen by business decision makers.

In most studies, Feldstein and Flemming (1971) Treasury model (1982) expected future output has been proxied using some function of current and past rates of output. For example, Feldstein and Flemming (1971) have replaced the current output variable Q by an expression of the form:

$$Q_t^{+} (1 + g+)^{q_0} (1 + g_t)^{q_0} (1 + g_{t-1})^{q_1} \ldots (1+g_{t-m})^{q_m} Q_t \tag{3.25}$$

Where g+ is the expected long-run growth rate and g_{t-1} is the growth rate for the year ending in quarter t-i. However, he pointed out that :

"The constant term $(1 + g^{+})^{q}$ plays no part in the empirical analysis."

Thus even if this long run growth rate is included, the output level for which the firm plans its capital stock reflects only past growth rates.

As far as the expectation of the production function is concerned, Jorgenson did not take it into account because he assumed a putty-putty production function. While Bischoff (1971) used a putty-clay production function thus making firm forward looking in their investment decisions.

Another contribution to the inclusion of the effects of expectations in the investment behaviour model is the study by Panic and Vernon (1975) who involved a linear variable to measure the level of business confidence, i.e. businessmen confidence accounted for by CBI survey of industrial trends and/or the Financial Times of industrial ordinary share prices deflated by index retail price. The latter was found to perform better at manufacturing sector as a whole, and in six major industrial groups. Indeed, for some industries the change in F.T. Index may contain additional information on expectations which is not contained in either current or lagged value of other variables. However changes in share prices may be due to changes in the cost of capital. Thus the confusion between the expectational effects and the cost of capital effects of changes in share prices makes it a difficult variable to use in investment demand equations because the firms investment decision is influenced in very different ways by expectational changes and changes in the cost of capital.

The C.B.I. Surveys of industrial trends over a wide area of activity may be more reliable. Using direct approaches - questionnaires and interviews - may be more accurate. Similarly data on forward looking indicators may be collected from economic trends which give an account of the inquiries made by the Department of Trade and Industry on the returns on investment intentions of large companies in the manufacturing as well as other industries.

Finally, Tideman (1975) in an analytical study criticized the derivation of the user cost of capital in the neoclassical model. The criticisms primarily directed at the omission of inflation adjustments for the financing cost term (r) and the failure to recognise the inflation taxation interaction on the present value of the depreciating deduction variable. Tideman developed an alternative specification for the user cost of capital that included inflationary effects.

A formulation of the user cost of capital similar to Tideman's was employed by Feldstein (1982) in an empirical study of inflationary effect on the determinants of investment demand. Like Tideman, Feldstein contended that inflation affects the cost of fund (r) and the present value of the depreciation deduction variable in the user cost of capital and that the omission of inflationary effects will bias the result. Feldstein adjusted (r) to reflect the real net cost of the use of debt and defined (r) to be a weighted average of debt and equity. Moreover his formulation recognised that during a period of inflation, fixed debt will be paid in future depreciated units thus the real cost will be less than the nominal cost.

Using similar reasoning the present value of the depreciation deductions variable is fixed and declines when the rate of inflation rises. To compensate for this effect Feldstein discounted the future depreciation deductions using the nominal cost of funds. The nominal cost of funds used as the discount rate was the real cost of funds, plus the rate of inflation. Using the above adjustments Feldstein argues that the models explanatory power (as measured by R^2) was increased and that the investment cycles were more accurately predicted.

In addition to the effects of inflation on investment brought about by historic cost depreciation rules, Malkiel (1979) Cuckierman (1980) Friedman (1980) and Levi and Makin (1979) suggest that inflation uncertainty has played a significant role in discounting real capital investment. Increases in inflation uncertainty measured by changes in the variance of forecasts of expected inflation reduce investment by:

(1) Increasing the hurdle-rate on investment projects

(2) Increasing the time and expense required to investigate and play uncertain ventures, and

(3) Reducing the general level of output

The effects of inflation and inflation uncertainty by investment is analysed in the next two chapters.

3.5 Conclusions

The preceding discussion has presented several recognised variations of the theory of investment behaviour. Each method seems to provide a reasonable explanation of investment activity. However for the purposes of this study the neoclassical econometric model of investment is relevant to the problem of quantifying the effects of inflation and historic cost depreciation on investment primarily for two reasons.

First, because the model is derived from conditions of profit maximization by a neoclassical firm, changes in investment behaviour can be traced to changes in cost. Therefore it is appropriate to predict that net and gross investment will react to specific economic conditions such as inflation which determine user cost. Thus the investment demand equation represents a consistent methodology for quantifying the effects of inflation because the mechanism by which such effects can occur is made explicit.

The second reason is based on the conclusion reached (see next chapter) in the analysis of the user cost. Specifically it is shown that one cannot assess the effects of inflation on depreciation and investment without explicit recognition of other important variables. Quantitative predictions of the effect of inflation on the level and composition of investment can be made with accuracy only when the effects of the level of tax rates, real interest rates, prices of investment goods, inflation rates, the effect on output by inflation have been accounted for, something which the neoclassical model satisfies.

Furthermore, a key advantage of the neoclassical investment model is its flexibility in incorporating variations and accommodating relaxed assumptions. The criticisms of the basic model then should not be viewed as sufficient to warrant rejection. Instead, because of its flexibility the criticisms should be viewed as issues requiring modification to the basic model.

Next we turn to the theoretical results which link inflation and historic cost depreciation to the level and composition of investment.

CHAPTER IV

INFLATION, DEPRECIATION DEDUCTIONS AND CAPITAL FORMATION

Three different methodologies have been employed to derive basic propositions regarding the link between inflation, historic cost depreciation and capital formation. The first approach, associated with Hendershott and Hu (1981c), is based on an analysis of the user cost of capital also known as the shadow price of real capital. Hendershott and Hu find that: (1) by reducing the present value of depreciation deductions on all classes of assets, inflation has reduced the overall demand for capital, and (2) inflation has distorted the choice of asset durability towards longer life structures. These results are derived analytically after careful specification of the user cost to include the relevant tax variables and the distinction between replacement and historic cost depreciation.

The second approach, discussed independently by Feldstein (1981a) and Kopcke (1981), focuses on the "net cost" of investment. By calculating net costs for various assets at different inflation and interest rates, these authors agree with Hendershott and Hu's first conclusion that inflation reduces the overall level of investment demand. However in contrast to the second conclusion Feldstein and Kopcke argue that inflation distorts the choice of asset durability towards equipment rather than structures.

The third approach is based on the concept of effective tax rates. Auerbach (1979, 1981) analyzes the effect of inflation on the effective tax rates for capital assets of different durability. The results suggest that inflation reduces the demand for capital and biases this choice toward more durable structures. Similar results using the effective tax rate methodology have been obtained by Hulten and Wukoff (1981).

Each of these models is discussed and analyzed in this chapter. The analysis demonstrates that the "net cost of investment" approach does not represent an appropriate methodology for analyzing the effect of inflation on the composition of asset demand. Under different assumptions about inflation, real interest rates, and asset service lives, the net cost of investment approach leads to ambiguous conclusions regarding the effect of inflation on investment composition. This ambiguity arises out of improper consideration for the differential importance of depreciation deductions between equipment and structures, and may be analytically demonstrated.

One surprising result of the analysis of these models, however, is that both the user cost and effective tax rate methodologies generate ambiguous results regarding the composition of asset demand under specific economic conditions. The effects of inflation on investment composition can vary over time as economic conditions evolve indicating that measurement of the historical link between inflation depreciation and investment is primarily an empirical question. Unfortunately, however the available econometric evidence on this topic is not sufficient in measuring the effect of inflation on either the level or composition of investment demand.

The purpose of this chapter is threefold (1) to present the basis of theoretical propositions concerning the relationship between inflation and the level and composition of gross investment; (2) to reconcile the divergent results regarding the effect of inflation on investment composition as obtained by Hendershott and Feldstein; and (3) to discuss the potential ambiguity in both the user cost and effective tax rate methodologies of determining the effects of inflation on investment composition.

4.1 Inflation and the User Cost of Capital

The concept of the user cost of capital is motivated by the neoclassical idea that business firms value each unit of capital input according to the opportunity cost of the funds used to acquire the asset. The user cost is essentially the real rental rate that a firm pays to obtain a pounds worth of real capital. In a world with no taxes and perfect capital markets, the user cost of capital will equal the required rate of return paid on financial assets plus the rate of economic depreciation. However in a world of corporate income taxes, accelerated depreciation, and inflation, the user cost will deviate from the no-tax world. For this reason it is important, when discussing the opportunity cost of acquiring capital goods, to account for all relevant tax and no-tax factors which may affect the investment decision.

The decision to invest depends on whether the present value of the expected return from an investment, net of direct operating expenses and direct taxes, exceeds the purchase price of the asset; on marginal investments the two values will be equal. Assume that inflation is expected to cause net revenues and the supply price of capital to rise at the rate p*, and that the productivity of the investment and thus real net revenues are expected to decline at the economic depreciation rate of d per year. Equilibrium in the capital goods market requires that the asset purchase price equal the discounted presented value of all capital services from the asset, where the discount factor equals the market rate of return. Assume that this rate of return is exogenous to the individual firms, and that any risk premium component of this rate of return remains constant. In a world with no taxes, the asset market equilibrium condition can be expressed as follows.

$$P_K = \sum_{t=1}^{\infty} \frac{(1 + p^* - d)^{t-1}}{(1 + r)^t} P_Y \rho \tag{4.1}$$

where

P_K = the market price of capital (current prices)

P_Y = the market price of output (current prices)

ρ = the marginal product of capital

d = the rate of economic depreciation

r = the market nominal rate of return (weighted average of the nominal rates of return on debt and equity finance)

p^* = expected inflation rate

By the infinite sum rule [1]:

$$\sum_{t=1}^{\infty} \frac{(1 + p^* - d)^{t-1}}{(1 + r)^t} = \frac{1}{r - p^* + d} \qquad (4.2)$$

Therefore the condition of equilibrium in the asset market may be restated as

$$P_K = \frac{\rho P_Y}{r - p^* + d} \qquad (4.3)$$

According to the neoclassical theory of the firm, in equilibrium the marginal product of capital will equal the real user cost (rental rate). An expression for the user cost may therefore be derived from (4.1).

$$\rho = c^* = \frac{P_K}{P_Y} (r - p^* + d) \qquad (4.4)$$

where c* is the real user cost of capital.

In a world without taxes the user cost of capital will equal the sum of (1) the real rate of return to equivalent investment of amount (P_K/P_Y), and (2) the cost associated with the decline in productivity of the investment by physical deterioration of the

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(1) See Hendershott and Hu (1981c)

capital. If the marginal product of capital exceeds the real user cost, the firm will increase its stock of real capital. If, however the user cost of capital increases relative to the initial marginal product of capital, firms will reduce their stock of real capital. Changes in the real user cost therefore give rise to net investment (disinvestment) as firms increase (decrease) the optimal stock of capital.

Equation (4.1) ignores the existence of income taxes, and the possibility that true economic depreciation may differ from tax depreciation. Assume that true economic depreciation is valued at replacement cost, and for the moment, assume that the firm is allowed to value tax depreciation at replacement rather than historic cost.

Rewriting (4.1) to account for these assumptions.

$$
\begin{aligned}
P_K = \sum_{t=1}^{\infty} (1 + r)^{-t} \Big[& (1 + p^* - d)^{t-1} (1 - TX) \rho P_Y \\
& + d (1 + p^* + d)^{t-1} TXP_K \\
& + \Big[d_{TX} (1 + p^* - d_{TX})^{t-1} \\
& - d (1 + p^* - d)^{t-1} \Big] TXP_K \Big] \qquad (4.5)
\end{aligned}
$$

where

$$r = (1 - TX)\, bi + (1 - b)\, e \qquad (4.6)$$

and

d_{TX} = rate of tax depreciation.

TX = corporate income tax rate.

b = portion of asset that is debt financed.

e = nominal after-tax return to equity.

i = nominal return on corporate debt.

The second term inside the large braces of (4.5) represents the portion of depreciation allowances just sufficient for true economic depreciation to replace worn out capital. The third term represents the tax savings from the difference between the value of the depreciation deduction under the tax law and that consistent with true economic depreciation. Accelerated rates of tax depreciation increase the third term inside the braces of (4.5), thereby increasing the tax savings and cash flow to the firm. From expression (4.5) it is possible to solve for the user cost of capital by employing the infinite sum rule once again.

$$\rho = c^* = \frac{P_K}{P_Y} \left[\frac{1}{(1 - TX)} (r - p^* + d) - \frac{TX \cdot d}{1 - TX} \right.$$

$$+ \frac{TX}{1 - TX} \left[d - (r - p^* + d) \sum_{t=1}^{\infty} \frac{d_{TX} (1 + p^* - d_{TX})^{t-1}}{(1 + r)^t} \right] \tag{4.7}$$

Note that for any given real supply price of capital (P_K/P_Y), the user cost of capital will decline as the excess of tax depreciation over economic depreciation increases (the third term inside brackets of (4.7)), with expression (4.7) it is possible to analyze the effect of inflation on the user cost of capital by focusing on the difference between economic depreciation and tax depreciation.

We can define the net addition to (or reduction in) the real user cost of capital associated with the difference between economic and tax depreciation as

$$DEPR = \frac{P_K}{P_Y} \frac{TX}{1 - TX} \left[d - (r - p^* + d) \sum_{t=1}^{\infty} \frac{d_{TX} (1 + p^* - d_{TX})^{t-1}}{(1 + r)^t} \right] \tag{4.8}$$

If the rate of tax depreciation (d_{TX}) established by law is exactly equal to the economic rate of depreciation (d), and both depreciation values are computed at replacement cost, then by the infinite sum rule:

$$DEPR = \frac{P_K}{P_Y}\frac{T_X}{1 - TX}\left[d - \frac{(r - p^* + d)\ d_{TX}}{(r - p^* + d_{TX})}\right] = 0 \quad (4.9)$$

when the rates of depreciation are exactly the same, and when the depreciation deductions (economic and tax) are valued at replacement cost, inflation has no impact on the cost of capital.

If however, the rate of tax depreciation exceeds that of economic depreciation, and we retain the assumption of replacement cost valuation, then:

$$DEPR = \frac{P_K}{P_Y}\frac{TX}{1 - TX}\left[d - \left[\frac{r - p^* + d}{r - p^* + d_{TX}}\right] d_{TX}\right] < 0 \quad (4.10)$$

Acceleration of the rate of tax depreciation relative to economic depreciation will reduce the cost of capital when the depreciation is valued at replacement cost.

However in most countries firms are required to value depreciating capital at the "historic" or original purchase price of the asset. Under this restriction $p^* = 0$ in the construction of the tax depreciation variable for expression (4.8) and the difference between economic and tax depreciation reduces to:

$$DEPR = \frac{P_K}{P_Y} \frac{TX}{1 - TX} \left[d - (r - p^* + d) \sum_{t=1}^{\infty} \frac{d_{TX} (1 - d_{TX})^{t-1}}{(1 + r)^t} \right]$$

$$= \frac{P_K}{P_Y} \frac{TX}{1 - TX} \left[d - \frac{(r - p^* + d)}{(r + d_{TX})} d_{TX} \right] \qquad (4.11)$$

which will be less than the difference between economic and tax depreciation computed in (4.10). By computing the difference between the cost of capital under historic cost depreciation (c^*_{HIST}) and the cost of capital assuming replacement cost depreciation (c^*_{REP}) it is possible to highlight the combined effect of inflation and historic cost depreciation on the cost of business investment:

$$c^*_{HIST} - c^*_{REP} = - \frac{P_K}{P_Y} \frac{TX}{1 - TX} (r - p^* + d) \left[\frac{1}{r + d_{TX}} - \frac{1}{r - p^* + d_{TX}} \right] d_{TX} > 0 \qquad (4.12)$$

The fact that firms value capital assets at historic cost, results in a higher user cost of capital if the inflation rate is positive. In the expression above the effect of inflation on the cost of capital results from an increase in the nominal rate of interest relative to the "real" rate of interest. When depreciation deductions are valued at historic cost, the present value of these deductions will decline with increases in the rate of inflation. This effect is captured in (4.12) by the relationship between the terms inside the brackets. At positive levels of inflation the first term inside the brackets declines relative to the second term as the nominal rate rises with the inflation rate. The higher the rate of inflation, the greater will be the increase in the user cost of capital under historic cost depreciation relative to replacement cost. With a zero rate of inflation, $p^* = 0$ and $(c^*_{HIST} - c^*_{REP}) = 0$.

The effect of inflation on the user cost of capital is significant for all classes of assets, given historic cost valuation of depreciating capital. Because inflation increases the user cost of capital on all classes of assets, in equilibrium the optimal stock of capital will be less than that which would exist in a non-inflationary world. As the optimal stock of capital declines, the amount of gross investment also declines.

This methodology may also be used to derive specific results regarding the effect of inflation on the relative user costs of equipment and structures capital. Referring to expression (4.12) assume that the rate of economic depreciation d equals the rate of tax depreciation dTX. This assumption is maintained for explanatory purposes only and may be eliminated without affecting any of the results. When d = dTX, expression (4.12) reduces to:

$$c^*_{HIST} - c^*_{REP} = - \frac{PK}{P_Y} \frac{TX}{1 - TX} \left[\frac{d_{TX} (r - p^* + d_{TX})}{(r + d_{TX})} - \frac{d_{TX} (r - p^* + d_{TX})}{(r - p^* + d_{TX})} \right] = - \frac{P_K}{P_Y} \frac{TX}{1 - TX} \left[\frac{-d_{TX} P^*}{r + d_{TX}} \right] > 0 \tag{4.13}$$

Taking the derivative of (4.13) with respect to d_{TX}, it is possible to examine the relationship of the magnitude of $(c^*_{HIST} - c^*_{REP})$ to the economic depreciation rate. From (4.13),

$$\frac{\delta (c^*_{HIST} - c^*_{REP})}{\delta d} = - \frac{P_K}{P_Y} \frac{TX}{1 - TX} \left[\frac{-rp^*}{(r + d_{TX})^2} \right] > 0 \tag{4.14}$$

The magnitude of the increase in the user cost of capital given historic cost depreciation is an increasing function of the rate of economic (tax) depreciation. Therefore, the shorter is the economic life (the higher is economic depreciation rate), the more historic cost depreciation discriminates against the investment (the higher is the user cost of capital). As the inflation and economic depreciation rates increase, the analysis suggests that the user cost of equipment capital should rise relative to the user cost of structures. With positive rates of inflation, ceteris paribus, business firms would reduce the optimal stock of equipment capital relative to that of structures capital, distorting the composition of business investment toward structures.

The result that inflation biases the composition of investment toward structures capital runs counter to the conclusions reached by Feldstein (1981a) and Kopcke (1981). In contrast to Hendershott and Auerbach, these authors suggest that inflation has biased the composition of investment toward assets with shorter lives, basing their analysis on an examination of the present value of tax depreciation deductions under current allowable asset lifetimes and depreciation methods.

It is shown below that these divergent conclusions regarding the effect of inflation on investment composition may be reconciled within the framework of the user cost of capital. This can be achieved by further interpreting the results obtained by Hendershott using a simplified expression for the user cost of capital.

Rewriting (4.7)

$$\rho = c^* = \frac{P_K}{P_Y}\left[\frac{1}{(1 - TX)}(r - p^* + d) - \frac{TX}{1 - TX}(r-p^*+d) \sum_{t=1}^{\infty} \frac{d_{TX}\,(1 + p^* - d_{TX})^{t-1}}{(1 + r)^t}\right] \tag{4.15}$$

Therefore

$$\rho = c^* = \left[\frac{1}{1 - TX}\right]\left[\frac{P_K}{P_Y}\right](r - p^* + d)(1 - TX\ Z) \tag{4.16}$$

where

$$Z = \sum_{t=1}^{\infty} \frac{d_{TX}\,(1 + p^* - d_{TX})^{t-1}}{(1 + r)^t} \tag{4.17}$$

The result obtained by Hendershott summarized in expression (4.16) suggests that the net effect of an increase in inflation is to raise the user cost of capital more for equipment than for structures. To interpret this result, consider the difference in the magnitude of the role depreciation deductions play in the determination of the user cost of employing equipment versus structures capital. Note that in expression (4.16) any changes in the value of Z are magnified by the value of (r - p* + d). For example, if Z declines, the bracketed term (1 - TX Z) increases, and the user cost of capital is increased accordingly. However the absolute effect on the user cost of capital will depend on the magnitude of 1/(1-TX), (P_K/P_Y), and (r-p*+d). But with any given values of the first two the increase in the user cost will be larger the higher is the economic depreciation rate.

Hendershott's result is a recognition of the relative importance of depreciation in the determination of the relative costs of employing equipment versus structures capital. In real terms, tax depreciation deductions allow firms the opportunity to recover the real cost of depreciable plant and equipment "used up" in the current period production of goods and services. Because equipment depreciates at a faster rate than structures (i.e. has a shorter economic life), greater deductions must be allowed in each period for equipment capital in order for the firm to replace such capital at a faster rate. More important, however is the fact that any changes in a firm's ability to recover the "used up" capital will be of greater importance to firms employing equipment capital simply because depreciation represents a substantially greater proportionate cost to the firm in each period than for structures capital. In other words any changes in the real value of tax depreciation deductions (Z) will be of greater importance for assets which depreciate at a faster rate. In terms of notation, since d for equipment in expression (4.16) is greater than d for structures, any change in the value of (1 - TX Z) will be magnified into greater absolute increases in the user cost for equipment relative to structures capital. It is important however to outline that Hendershott and Hu do not believe that inflation reduces the present value of tax depreciation deductions Z more for equipment than for structures, as the basis for their conclusion. Rather, the focus of their analysis is the net effect of changes in Z on the relative cost of employing assets with different economic depreciation lifetimes.

4.2 Inflation and the Net Cost of Investment

Instead of focusing on the net effect of inflation and historic cost depreciation on the user cost of capital, Feldstein (1981a) and Kopcke (1981) analyze the behaviour of the expression (1 - TX Z) subject to different depreciation methods, lifetimes, and inflation rates. It is through an analysis of this variable that they conclude separately that the effect of inflation is to bias the composition of investment in the opposite direction i.e. toward equipment and against structures. Feldsteins results are outlined below.

Consider an asset that can be depreciated over N years. The economic life of the asset i.e. the number of years until it is scrapped, may also be N years, but it need not be; the economic life of the asset is irrelevant in calculating and comparing the net cost of the investment. The fraction of the initial cost of the investment that can be deducted as a depreciation expense in year t under the existing historic cost method of depreciation is denoted as DHt. If (TX) is the corporate tax rate, the reduction in other tax liabilities in year t is TX DHt.

Let R denote the real discount rate that firms use to calculate the present value of future tax savings resulting from allowable depreciation. In the absence of inflation, the net cost per unit of investment may be written:

$$C_H = 1 - TX \sum_{t=1}^{N} \frac{DH_t}{(1 + R)^t} \tag{4.18}$$

Note that this expression is identical to the expression (1 - TX Z) shown in equation (4.16).

Inflation reduces the real value of the depreciation allowed in future years. If the inflation rate is constant at i per-cent per year, the real value of the depreciation in year t is DH_t $(1 + i)^{-t}$. With positive inflation rates and historic cost depreciation rules, the net cost per monetary unit of investment can be calculated by discounting the resulting real depreciation at the original real discount rate:

$$C_H = 1 - TX \sum_{t=1}^{N} \frac{DH_t(1 + i)^{-t}}{(1 + R)^t}$$

$$= 1 - TX \sum_{t=1}^{N} \frac{D\ H_t}{(1 + R)^t\ (1 + i)^t} \tag{4.19}$$

If, however, depreciation deductions were valued at replacement cost (i.e. indexed), then the expression for net cost (CI) may be written as:

$$C_I = 1 - TX \sum_{t=1}^{N} \frac{DH_t\ (1 + i)^t\ (1 + i)^{-t}}{(1 + R)^t}$$

$$= 1 - TX \sum_{t=1}^{N} \frac{DH_t}{(1 + R)^t} \tag{4.20}$$

The increase in the nominal amount of allowable depreciation exactly offsets the fall in the real value of the money, leaving the net cost of investment independent of the rate of inflation.

Calculating the difference in net costs under historic versus replacement cost depreciation, the following relationship holds:

$$C_H - C_I = \sum_{t=1}^{N} \frac{DH_t}{(1 + i)^t \ (1 + R)^t} - \sum_{t=1}^{N} \frac{DH_t}{(1 + R)^t} \tag{4.21}$$

Inflation raises the net cost of investment when historic cost depreciation is required suggesting that investment in all asset types would decline. Hence, Feldstein and Hendershott and Hu (as well as Kopcke) are in agreement over the effect of inflation on the aggregate level of investment. However, the difference in the conclusions regarding investment composition can be illustrated in terms of the numerical examples presented by Feldstein.

Table 4.1 and Table 4.2 present Feldstein's calculations of the relative net cost of equipment investment and structures, with existing historic cost depreciation rules. The numbers in the tables represent ratios of the net cost of equipment investment with the specified rate of inflation divided by the net cost when there is no inflation, as:

$$(4.22)\quad \frac{C_H\ (p^* > 0)}{C_H\ (p^* = 0)} = \frac{1 - TX \sum_{t=1}^{N} \frac{DHt}{(1 + R)^t\ (1 + i)^t}}{1 - TX \sum_{t=1}^{N} \frac{DHt}{(1 + R)^t}}$$

These relative net cost ratios are presented for different combinations of the real discount rate and allowable tax lives.

From equation (4.22) the ratio of net costs rises above the value of unity as the inflation rate increases from i = 0. This is due, as mentioned earlier, to the decline in the real present value of depreciation deductions which effectively raises the net cost of investment.

Feldstein draws two primary conclusions from the sample calculations presented in Tables 4.1 and 4.2. The first conclusion concerns the effect of inflation on the aggregate level of investment for equipment and structures. Both Tables 4.1

and 4.2 suggest that increases in the rate of inflation, for any given real rate of interest and asset lifetime, generate an increase in the net cost of investment in all circumstances. As the inflation rate increases therefore, investment in assets of all economic or tax lifetimes would decline.

The second conclusion concerns the effect of inflation and historic cost depreciation on the composition of investment. From the evidence presented in Tables 4.1 and 4.2 Feldstein concludes that inflation clearly raises the net cost of short-lived investments by relatively less than the increase in the net cost of long-lived assets, and therefore distorts the pattern of investment in favour of short-lived assets. The basis of this conclusion is the frequency with which increases in asset lifetimes give rise to increases in the net cost ratio for any given real interest and inflation rate. Note, however, that this particular conclusion is based primarily on frequency of pattern, rather than monotonicity of result. For example when the real interest rate is zero, increases in asset lifetime given different inflation rates generally correspond to increases in the net cost ratios for both equipment and structures.

TABLE 4.1

THE RELATIVE NET COST OF INVESTMENT IN STRUCTURES WITH EXISTING HISTORIC COST DEPRECIATION RULES

Real Discount Rate	Inflation Rate	Allowable Depreciation Life (Years) 8	13	18	25	35
0.00	0.00	1.00	1.00	1.00	1.00	1.00
	0.04	1.12	1.18	1.23	1.30	1.37
	0.08	1.22	1.31	1.38	1.46	1.53
	0.12	1.30	1.40	1.47	1.55	1.62
	0.16	1.36	1.47	1.54	1.61	1.67
0.04	0.00	1.00	1.00	1.00	1.00	1.00
	0.04	1.09	1.11	1.12	1.13	1.12
	0.08	1.16	1.19	1.20	1.20	1.18
	0.12	1.21	1.25	1.25	1.24	1.22
	0.16	1.26	1.29	1.29	1.28	1.24
0.07	0.00	1.00	1.00	1.00	1.00	1.00
	0.04	1.07	1.08	1.08	1.08	1.07
	0.08	1.13	1.14	1.14	1.13	1.11
	0.12	1.17	1.18	1.18	1.16	1.13
	0.16	1.21	1.22	1.20	1.18	1.14

Source : Martin Feldstein (1981a)

TABLE 4.2

THE RELATIVE NET COST OF INVESTMENT IN EQUIPMENT WITH EXISTING HISTORIC COST DEPRECIATION RULES

Real Discount Rate	Inflation Rate	Allowable Depreciation Life (Years)					
		3	8	13	18	25	35
0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00
	0.04	1.05	1.13	1.18	1.23	1.29	1.37
	0.08	1.09	1.23	1.31	1.39	1.47	1.56
	0.12	1.13	1.31	1.41	1.50	1.58	1.67
	0.16	1.17	1.38	1.49	1.58	1.66	1.75
0.04	0.00	1.00	1.00	1.00	1.00	1.00	1.00
	0.04	1.04	1.09	1.12	1.13	1.14	1.15
	0.08	1.08	1.17	1.21	1.22	1.23	1.23
	0.12	1.12	1.23	1.27	1.29	1.30	1.28
	0.16	1.15	1.29	1.33	1.34	1.34	1.32
0.07	0.00	1.00	1.00	1.00	1.00	1.00	1.00
	0.04	1.04	1.08	1.09	1.09	1.09	1.09
	0.08	1.08	1.14	1.16	1.16	1.16	1.14
	0.12	1.11	1.19	1.21	1.21	1.20	1.18
	0.16	1.14	1.24	1.25	1.25	1.23	1.20

Source : Martin Feldstein (1981a)

However when the real rate of interest is greater than zero and the inflation rate is high, increases in asset lifetimes often lead to declines in the net cost of investment. Feldstein basically concludes that over feasible ranges of inflation rates asset lifetimes and real interest rates, the combined effect of inflation and historic cost depreciation generates a bias in the composition of investment towards equipment.

In summary, Feldstein argues that inflation (1) reduces the level of aggregate investment over all asset lifetimes, and (2) causes a greater decline in investment in long-lived assets. It is the second of the two conclusions which runs against the results obtained by Hendershott and Hu regarding investment composition.

Since the sample calculations and economic model discussed by Feldstein are very similar to those found in the recent work of Kopcke, the latter results are not presented here. However, it is interesting to note that the relationship of the net cost ratios to increases in asset lifetimes are also non-monotonic in Kopcke's calculation of net cost.

4.2.1 Ambiguity in Net Cost Approach

The difference in the conclusions reached by Feldstein and Hendershott and Hu is the result of the divergent methodologies used by the respective authors. On the one hand, Hendershott and Hu employ the notion of the user cost of capital, where as Feldstein bases his analysis on the behaviour of tax depreciation deductions within the simplified framework of the net cost of investment. Feldstein's results regarding the effect of inflation on investment composition, however, are found to be non-monotonic with respect to asset life. By employing expression (4.12) reproduced below, it is possible to demonstrate analytically why this ambiguity occurs, and also to show that results regarding the effect of inflation on asset composition may be obtained only in the context of the user cost of capital.

Recall expression (4.12) which qualifies the relationship between the user cost under historic versus replacement cost depreciation,

$$c^*_{HIST} - c^*_{REP} = - \frac{P_K}{P_Y} \frac{TX}{1 - TX} (r - p^* + d) \left[\frac{d_{TX}}{r + d_{TX}} - \frac{d_{TX}}{r - p^* + d_{TX}} \right] > 0 \qquad (4.23)$$

where

$$\frac{\delta(c^*_{HIST} - c^*_{REP})}{\delta d} = - \frac{P_K}{P_Y} \frac{TX}{1 - TX} \left[\frac{-rp^*}{(r + d_{TX})^2}\right] > 0 \tag{4.24}$$

Further, recall that the difference in the net costs of investment using Feldstein's methodology can be represented as:

$$c^*_H - c^*_R = - \left[\sum_{t=1}^{N} \frac{DH_t}{(1 + R)^t (1 + i)^t} - \sum_{t=1}^{N} \frac{DH_t}{(1 + R)^t} \right] > 0 \tag{4.25}$$

Note the similarity in the right-hand bracketed term in (4.23) to that of (4.25). These two terms are identical in that they both measure the magnitude of the difference between depreciation deductions under historic and replacement cost valuation.

Therefore expression (4.25) can be reduced to:

$$c^*_H - c^*_R = - \left[\frac{d_{TX}}{r + d_{TX}} - \frac{d_{TX}}{r - p^* + d_{TX}} \right] > 0 \tag{4.26}$$

where

r = nominal rate of interest.

$r - p^*$ = real rate of interest.

From this analysis it is clear that the concept of the net cost of investment employed by Feldstein is one component of the change in the user cost of capital due to historic cost depreciation.

Expression (4.26) may be used to demonstrate that in isolation the change in the net cost of investment is ambiguous with respect to changes in the economic depreciation rate (i.e. economic service life). Further it can also be shown that the direction of change in the relative cost of equipment versus structures investment is not ambiguous when one accounts for the differential significance of depreciation deductions in the calculation of economic cost.

First, differentiate expression (4.26) with respect to d_{TX}:

$$\frac{\delta(c^*_H - c^*_R)}{\delta d_{TX}} = - \left[\frac{r}{(r + d_{TX})^2} - \frac{r}{(r - p^* + d_{TX})^2} + \frac{p^*}{(r - p^* + d_{TX})^2} \right]$$

$$\gtreqless 0 \text{ (ambiguous).} \qquad (4.27)$$

Note that the sum of the first two terms inside the brackets is negative. Considering these two terms in isolation, the net effect of decreasing the depreciation rate (i.e. increasing the economic lifetime) would be to decrease unambiguously the net cost of investment. However, since the third term inside the brackets is a positive value, expression (4.27) represents the sum of offsetting positive and negative magnitudes, and the sign of the expression (4.27) is theoretically ambiguous. Therefore for any given real interest rate a positive inflation rate could result in a negative sign for expression (4.27), suggesting that a fall in the depreciation rate dTX (i.e. an increase in economic life) would result in an increase in the net cost of investment as Feldstein suggests.

This ambiguity was demonstrated in numerical terms by both Feldstein and Kopcke. Therefore, by simply examining the relationship of changes in the net cost of investment and changes in economic lifetime, the effect of inflation on asset composition cannot be determined unambiguously. The effect of inflation on the net cost of investment depends jointly on the level of real interest rates and inflation rates as well as asset lifetimes.

In economic terms, resolution of the conflict between the net cost and user cost approaches may be interpreted as follows: the decision to invest in a non-depreciable asset depends on the ability of the asset to earn a given required rate of return r for the owners. This return may be thought of as the opportunity cost of capital as perceived by the investors. For depreciable assets, however, the investors must be concerned with earning not only r on the asset, but also some additional return d necessary to replace the capital used up in production. The sum of these two elements represents the gross return required by investors in order for the project to be acceptable. Assets with shorter economic lifetimes require a higher gross return per period in order to replace capital that physically deteriorates at a faster rate. Because short-lived assets require a higher gross return per period, they are more sensitive to changes in any of the factors which govern the assets ability to earn that return. Specifically, changes in the real value of depreciation deductions per unit of real capital have a much stronger impact on short-lived assets simply because owners of the asset must be concerned with replacing the depreciated capital at a much faster pace.

The user cost of capital approach explicitly allows for the difference in gross return required for assets of different service lifetimes, thereby allowing for differential sensitivities to changes in the factors which affect the asset's ability to earn such returns. The net cost approach focuses only on changes in the value of tax incentives, not recognizing the differential importance of such changes to assets of different service lives. As the above analysis demonstrates, when the relative importance of changes in tax incentives are appropriately accounted for, the ambiguity in the effects of inflation on investment composition disappears.

Before turning to an analysis of the effective tax rate methodology, it is interesting to note that Bradford (1981) has also identified the numerical inconsistency of the net cost approach, and further suggests that Feldstein's approach is not appropriate to the analysis of inflation and investment composition. Following Hendershott and Hu, Bradford chooses instead to base his analysis on the user cost methodology. He also concludes that inflation not only reduces the stock of real capital, but also biases the choice towards structures.

4.3 Inflation and Effective Tax Rates

Employing the concept of effective tax rates, Auerbach (1979, 1981) has attempted to derive specific results regarding the effect of inflation on capital formation. His model is interesting because it employs a general equilibrium framework to derive the steady-state effect of changes in inflation on the optimal composition of the capital stock. The results of Auerbach's analysis suggest that inflation biases the choice of asset durability toward assets with longer service lives, as claimed by Hendershott and Hu (1981c).

The basic model consists of a competitive economy with one production sector composed of firms which utilize two inputs, capital and labour, subject to a constant returns production technology. The price of new capital goods at time t is Pt, and the price of a unit of labour is Wt. Equity holders are assumed to discount nominally measured cash flows from the firm at a nominal interest rate r.

Capital goods decay exponentially at a constant rate δ which is assumed to be variable and subject to choice by the firm. An increase in δ represents an increase in the flow of capital services per unit of time from a unit of capital, such increases being subject to diminishing returns. This flow is represented by the function $A(\delta)$ where $(A' > 0)$ and $(A'' < 0)$. Gross output is defined by:

$$Y^G = H\ (KS,\ L) \qquad H_K,\ H_L,\ H_{KL} > 0$$

$$H_{KK},\ H_{LL} < 0 \qquad (4.28)$$

where H is homogeneous of degree one in its two inputs, labour (L) and capital services (KS). When It represents nominal investment at time t, and δ_t is the corresponding decay rate chosen by the firm, then the net capital stock remaining from this investment at time $S > t$ is $(I_t/P_t)e^{-\delta_t(S-t)}$. Total capital services derived from this investment by time S are

$$KS_s = \int_{-\infty}^{s} A(\delta_t)(I_t/P_t)\ e^{-\delta_t(S-t)d_t} \qquad (4.29)$$

Corporate profits are taxed at rate r after deduction of wages and depreciation allowances. Denote $D\ (X,\delta)$ as the deduction permitted per unit of initial investment for an asset of age X which decays at rate δ. The objective of the firm in this economy is to maximize shareholders current wealth. The firm accomplishes this by maximizing its own present value:

$$V = \int_{o}^{\infty} e^{-rt} \left[(1 - r)(PY_t^G - W_t L_t) - I_t + \right.$$

$$\left. + \int_{-\infty}^{t} I_s \, D\,(t - S, \delta_s)\, d_s \right] d_t \qquad (4.30)$$

Differentiating V first with respect to δ_t, I_t, and L_t, and then differentiating the whole system of equations again with respect to r , Auerbach obtains the following steady-state conditions for present value maximization.

$$\frac{\delta c}{\delta s} = 0$$

$$H_K \, [A\,(\delta)\, K,\, L] = \frac{C}{P}$$

$$H_L \;\; A\,(\delta)\, K,\, L = \frac{W}{P} \qquad (4.31)$$

where

$c = P\,(\rho+\delta)(1 - \tau Z)/(1 - r)$ the user cost of capital.

P = real asset price, assumed to equal unity.

$\rho = r - \pi$, the real discount rate (equity holders required return).

π = expected rate of inflation.

$Z = \int_{o}^{\infty} e^{-rs}\, D\,(S,\delta)\, ds$, the present value of depreciations at time S on an asset which depreciates at rate δ.

The optimal steady-state behaviour of firms involves two steps. In the first step, firms minimize the implicit cost of capital services (c) by their choice of δ. Second, firms then maximize profits by employing labour and capital until their respective marginal products equals their marginal costs.

Auerbach examines the effect of inflation on effective tax rates for assets of different depreciation rates δ by introducing a distinction between ρ, the real rate of return paid to equity holders (assumed constant), and the gross rate of return which a firm must earn to pay equity holders ρ. Let V equal the firm's "implicit discount rate" where

$$V = [(\rho + \delta)(1 - \tau Z)/(1 - \tau) - \delta \qquad (4.32)$$

Because investors still receive a rate of return equal to ρ, the effective corporate tax rate equals

$$\Theta = (V - \rho)/ V \qquad (4.33)$$

If $\tau = 0$, $v = \rho$, and the effective tax rate is zero.

However if $\tau > 0$, the magnitude of Θ depends on the depreciation scheme (Z) and the chosen rate of capital decay δ. The effect of inflation on effective tax rates therefore must be analyzed by observing changes in Z.

From a unit of capital purchased at time t, the amount available at time S is $(1/P_t)e^{-\delta(S-t)}$ after physical depreciation of the asset. Multiplying this term by $(p_s\delta)$, the remaining depreciation deductions at time S valued at replacement cost is determined by:

$$D_R\ (S - t,\delta) = e^{-\delta(S-t)}(P_s/P_t) \tag{4.34}$$

The present value of these deductions is

$$Z_R = \delta/(\rho + \delta) \tag{4.35}$$

If a fraction e is expensed, the value of Z per unit of capital is

$$Z_R = e + (1 - e)\delta/(\rho + \delta) \tag{4.36}$$

substitution of Z into (4.32) result in

$$V = \rho(1 - \tau e)/(1 - \tau) \tag{4.37}$$

Therefore, the effective tax rate on corporate investment is

$$\Theta = \tau\ (1 - e)/(1 - \tau e) \tag{4.38}$$

with replacement cost depreciation, inflation does not alter the relative effective tax rates between different capital assets.

However if depreciation deductions are valued at historic rather than replacement cost, the results are significantly different. With historic cost depreciation

$$D_H\ (S - t,\delta) = \delta e^{-\delta(S-t)} \tag{4.39}$$

and the present value of these deductions equal

$$Z_H = \delta/(\rho + \pi + \delta) \tag{4.40}$$

Therefore

$$V = \rho/(1 - \tau) + \pi\tau Z_H/(1 - \tau) \tag{4.41}$$

and

$$\Theta = (\tau\rho + \pi\tau Z_H)/(\rho + \pi\tau Z_H) \tag{4.42}$$

Two features of the effective tax rates are apparent in the presence of historic cost depreciation and positive rates of inflation. First, if $\pi > 0$, Θ is greater than τ. Further, because Z_H is an increasing function of δ, $\delta\Theta/\delta\delta>0$, and the choice of asset durability is biased toward assets with low values of δ.

These results indicate that theoretical propositions regarding the effect of inflation on the composition of investment may be derived using either the concept of the user costs of capital or effective tax rates. In both cases, inflation is found to bias the choice of capital toward assets with longer service lives. The results obtained by Auerbach and Hendershott and Hu account for the relative importance of depreciation deductions in the choice between equipment and structures. Increases in inflation which affects the present value of depreciation deductions for equipment are magnified by the fact that equipment capital depreciates at a faster pace, and hence firms must recover such costs rapidly in order to earn an after-tax return of V on its assets.

4.3.1 Inflation and the Composition of Investment Demand: Potential Ambiguity

The user cost of capital reflects opportunity costs to the extent that it measures the cost of foregone interest payments and depreciation of physical capital. As the previous discussion indicates, changes in the structure of tax incentives (i.e. depreciation deductions) are magnified according to the level of the demand price (P_K/P_Y), and real interest and depreciation rates ($r - p^* + d$). As the asset demand price and real rate of interest increase, the magnitude of the effect of changes in the user cost of capital also increases. Therefore accurate predictions of the effect of inflation and historic cost depreciation on the level and composition of business investment cannot be determined without an understanding of other economic factors influencing the inflationary effects.

Note, however, that Hendershott and Hu's basic conclusion regarding the relationship of the user cost of capital and asset depreciation rate is also ambiguous under some conditions.

Taking the derivative of expression (4.23) with respect to the asset demand price P_K/P_Y yields the following result.

$$\frac{\delta(c^*_{REP} - c^*_{HIST})}{\delta(P_K/P_Y)} = - \frac{TX}{1 - TX}(r - p^* + d)$$

$$\left[\frac{d_{TX}}{r + d_{TX}} - \frac{d_{TX}}{r - p^* + d_{TX}} \right] > 0 \qquad (4.43)$$

The effect of inflation on the user cost of capital under historic cost depreciation rules is an increasing function of the asset purchase price. With higher real purchase prices, the inflationary effects are magnified reflecting the fact that the real value of depreciation deductions has increased considerably. If the initial real asset purchase price for structures was substantially greater than the price for equipment, the relative increase in the user cost of capital under replacement cost depreciation could be greater for structures. Under such conditions the effect of inflation on the optimal capital composition of the stock could well be reversed. Equation (4.14) earlier indicates that the effect of inflation on the user cost of capital is also an increasing function of the economic depreciation rate. Combined with expression (4.43), however, the net effect on the user cost of capital for equipment and structures is theoretically ambiguous and it is impossible to assess the net effect on the optimal composition of the capital stock. This result undervalues the conclusion that the effect of inflation and historic cost depreciation on investment composition can only be determined accurately when all components of cost are properly accounted for.

This same ambiguity is present in the analysis of effective tax rates discussed above. Recall from expression (4.31) and the definitions below (4.31) that Auerbach assumes that all real asset prices are constant and equal to unity. Therefore, the real asset price drops out of the calculation of effective tax rates for each asset class. However, if the real price of structures should be greater relative to the real price of equipment, the direction of the overall change in user costs or effective tax rates becomes theoretically ambiguous. For this reason, it is apparent that any attempt to measure the effect of inflation on the composition of investment must carefully account for the existing set of real asset purchase prices.

4.4 Conclusions

The analysis in this chapter indicates that by reducing the real value of depreciation deductions, inflation will lead to a decline in the real capital stock and investment. Hendershott, Feldstein, Kopcke, and Auerbach all suggest that inflation can substantially affect the real value of depreciation deductions when such deductions are governed by tax laws requiring historic cost depreciation. The above analysis also indicates that inflation can potentially affect the composition of the capital stock biasing the choice of assets toward structures. Differing conclusions regarding the effect of inflation on investment composition are resolved when the relative importance of tax factors between assets of differing service lives are properly accounted for.

One important conclusion of this chapter is that the calculation of the effect of inflation on the level and composition of the capital stock depends explicitly on the level of real interest rates and asset purchase prices. Only by properly accounting for given economic conditions can one quantify the effects of inflation on the incentives to invest in real capital.

This last conclusion has implications for selection of the appropriate econometric methodology. It suggests that proper measurement of the relation between inflation, historic costs depreciation, and actual investment behaviour requires explicit specification of all the relevant economic and tax variables which determine this relationship.

CHAPTER V

INFLATION AND CAPITAL FORMATION: EMPIRICAL EVIDENCE

The purpose of this chapter is to review two studies which address the empirical relation between inflation, depreciation deductions, and investment. Using the Jorgenson cost of capital model, Feldstein (1982) finds evidence that adjustment of the investment model for the effect of inflation on depreciation yields an improvement in explanatory power. Corcoran (1979) also reports statistical evidence of the importance of depreciation deductions on capital formation and indicates that inflation affects investment by reducing such deductions as suggested by the theory. These studies, however are found to be of very limited value in measuring the empirical link between inflation and the level and composition of investment demand. The following analysis indicates that the empirical relevance of inflation for explanations of investment behaviour remains essentially unexplored.

In addition to the direct effects of inflationary expectations, this chapter also discusses recent suggestions that inflation uncertainty has played a significant role in discouraging real capital investment. Malkiel (1979), Cuckierman (1981), and Friedman (1980) have stated that changes in inflation uncertainty, measured by changes in the variance of forecasts of expected inflation, have reduced investment by (1) increasing the hurdle rate on investment projects as a result of higher risk premiums, (2) increasing the time and expense required to investigate and plan more uncertain ventures, and (3) reducing the general level of output. Evidence on the effect of inflation uncertainty on saving behaviour, however, would seem to dispute these conclusions.

For example, Wachtel (1979) finds that an increase in inflation uncertainty increases saving which in effect should lead to an increase in investment. These arguments are discussed briefly in this chapter. Because no direct test of the hypothesis that inflation uncertainty has reduced investment has been attempted, such a test is proposed here.

5.1 Inflation Depreciation Deductions and Investment Empirical Evidence

The estimation equation employed by Feldstein (1982) may be summarised as follows:

$$I_t^G = \beta_0 + \sum_{j=0}^{n} V_j \Delta K^* + dK_t + \varepsilon_t \qquad (5.1)$$

where I_t^G = gross investment in period t

K^* = optimal capital stock, measured as the ratio

of output to the user cost of capital

K_t = actual capital stock in period t

d = depreciation rate

Because the user cost of capital enters directly into the investment equation through determination of K^*, inflation is an explanatory variable of the model. To provide evidence of the importance of inflation, Feldstein estimated the above equation for investment in producers durable equipment at the Non - Farm Business Sector level.

Using an expression identical to equation (4.16), Feldstein constructs values for the equipment user cost of capital using data on depreciation and tax rates, interest rates, and an assumed measure of inflationary expectations. Actually, two measures of equipment user cost are constructed: one measure which incorporates the effects of inflation, and a second measure which does not. For the first measure of user cost, depreciation deductions are valued at historic cost, whereas for the second measure they are valued at replacement cost.

To provide evidence that inflation affects investment, Feldstein formulates an econometric test of changes in the explanatory power of the investment model. By using the two different measures of user cost described above, he hoped to demonstrate that a failure to correct for inflationary bias in the user cost would reduce its ability to explain historical investment behaviour. Upon estimation of two separate models of equipment investment for the Non - Farm Business Sector, Feldstein does indeed observe some gain in the fit of the model. Specifically, he notes that when the correct measure of the user cost is employed in the estimation, (1) the adjusted coefficient of determination, $\bar{R}^2$, rises from .970 to .980 and (2) the sum-of-squared residuals falls to 112.3 from 167.4 On the basis of this evidence, Feldstein states:

> "It is of some importance that, even within the highly constrained assumptions of the present model, the data provide clear support for the responsiveness of investment to changes in a correctly measured cost of capital services in general and to changes caused by inflation in particular. Although the data are not rich enough to provide precise estimates of the responsiveness of investment to the individual components of

> the cost of capital, it is worth noting that the evidence shows that a correct accounting of the impact of inflation substantially improves the ability of the analysis to explain the variation in investment over the past 25 years".

In summary, because the statistical results suggest that a correct representation of the user cost improves the ability of the model to explain investment, Feldstein concludes that the effects of inflation have been substantial.

The conclusions drawn by Feldstein on the basis of the above econometric evidence may be criticized on two grounds. The first and perhaps most critical, problem with the results obtained by Feldstein is the nature of the empirical test. Essentially, he is comparing the results obtained from estimation of a model that is known to be misspecified against the results from a model that on theoretical grounds more closely approximates a "true" investment demand equation. By comparing models on the basis of some objective criteria, Feldstein hoped to assess the difference in quality of econometric "fit". However, because the first model employs a user cost variable which is measured incorrectly, it suffers the econometric problem of errors in variables. Under such conditions, the estimation results are known to be biased and inconsistent, and one must view these results with suspicion. Therefore, it is inappropriate to compare the results of these two models and to attach so much importance to changes in the objective measure of fit.

One additional problem with Feldstein's results is that they do not address the issue of the effect of inflation on the composition of investment. Feldstein's analysis is limited to the behaviour of investment in producer's durable equipment. Because no reference is made to the effects of inflation on the level of investments in structures it is impossible to know whether the same methodology applied to a structures equation would yield results similar to those for equipment. Therefore, one cannot assert that the level of aggregate gross investment would fall under inflationary conditions, or whether some adjustment in composition would result. Therefore, it is clear that any econometric test, whose purpose is to grantify the effects of inflation on both the level and composition of investment should handle both equations using the same methodology.

In an attempt to test the hypothesis that inflation reduces investment, Corcoran (1979) estimated the following model:

$$\left[\frac{I}{K}\right]_{jt} = \beta_o(R_j)_t + \beta_1(ITC_j)_t + \beta_3(DEP_j)_t + \varepsilon_t \qquad (5.2)$$

where:

I_j = Gross investment in asset type j at time t.

K_j = Capital stock for asset j at time t.

R_j = Rate of Return on Investment in asset j at time t.

ITC_j = Present value of the investment tax credit available on asset j at time t.

DEP_j = Present value of a dollars worth of investment in asset j at time t.

Equations were estimated using generalized least squares for seven different asset categories. The purpose of this test was to determine the sign and statistical significance of the coefficient β_3 in equation (5.2). A significant and positive coefficient on this variable was assumed to provide evidence that depreciation deductions are an important element in investment behaviour.

Corcoran does indeed find this result for each of the seven equations. He argues that because inflation reduces the present value of such deductions by raising the nominal discount rate, inflation is responsible for the decline in aggregate investment in the Non-Farm Business Sector. He further argues that because inflation reduces the present value of such deductions more for structures than for equipment, inflation has distorted investment composition toward equipment rather than structures.

Criticism of these results stems primarily from the conclusions drawn in chapter IV regarding the appropriateness of the net cost of investment approach for analyzing this problem. Specifically the previous analysis demonstrates that the effect of inflation on the present value of depreciation deductions varies according to the assumptions on the level of real interest rates and inflation rates. Further, the analysis of chapter IV indicates that simple analysis of the present value of depreciation deductions fails to account for (1) the differential importance of depreciation deductions between equipment and structures and (2) variations in the relative prices of equipment and structures over time. These findings suggest that the relationship between investment and simple calculations of the present value of depreciations will change as economic conditions evolve.

In econometric terms, this indicates that the estimated coefficients in Corcoran's equation are not constant over time and must be considered as unstable. Essentially, no economic significance can be attached to these coefficients and one must question whether they provide any information useful for policy analysis. It is interesting to note that Corcoran makes no attempt to interpret the coefficients or calculate changes in investment with respect to changes in inflation. Further, it is impossible to isolate from his results the change in investment generated by changes in tax laws governing allowable depreciation methods and lifetimes rather than inflation. For these reasons, Corcoran's empirical test provides essentially no econometric evidence that inflation has substantially affected capital investment in the United States.

Based on these criticisms one must assert that the results provided by Feldstein and Corcoran do not constitute sufficient evidence to conclude that inflation and historic cost depreciation have been a primary source of the current weakness in investment demand. Further, it is apparent that no econometric evidence exists which supports the hypothesis that inflation distorts the composition of investment. In summary, no real evidence exists to conclude that inflation is a significant deterrent to investment expenditure. However, because of the significance of this issue, and the complete lack of evidence in the U.K. it is clear that further empirical research is warranted.

5.2 Investment and Inflation Uncertainty

The previous chapter described the manner in which inflation affects the long-run level and composition of investment directly. Note that such effects are present even if economic agents are perfect forecasters of inflation as generally assumed. Inflation reduces the ability of depreciation deductions to shield real corporate income from taxation, and expectations of such effects will alter the level and composition of investment regardless of the expectations formation mechanism.

One aspect of the relation between inflationary expectations and investment, however has not received much attention. This problem concerns the effect of inflation uncertainty on investment. Inflation uncertainty is defined in this instance as the degree of variance in forecasts of inflationary expectations held by market participants at different points in time. Most research on price expectations assumes that the standard deviation of "market" price forecasts is constant across time, individuals and markets, suggesting that the second moment of such forecasts can be ignored. Recent evidence, however indicates that this usual assumption on price expectations is not consistent with survey measures of such expectations. A review of recent literature suggests that variation in the probability distribution of inflationary expectations could have real effects on the level and composition of investment. The problem with this literature, however, is that predictions of the effects of inflation uncertainty on investment are contradictory, and primarily based on guesses. The purpose of this section is to review basic elements in this literature and propose a simple empirical test of the hypothesis that inflation uncertainty has affected the level and composition of investment.

One avenue by which inflation uncertainty is thought to affect investment was suggested by Malkiel (1979). Describing possible reasons for sluggish investment, Malkiel suggested that high and variable rates of inflation have increased the risk associated with investment projects which has in turn raised the hurdle rate that investment projects must surpass before they are undertaken. This risk premium is calculated as the difference between anticipated rates of return on stocks and the rate of return on riskless Treasury securities. A plot of this risk premium reveals that it fell to a low point in the early 1970s, and has been increasing steadily ever since. The author suggests that the major reason for the premium has been the risk of uncertain cash flows to investment caused by high and variable rates of inflation. An increase in the risk premium associated with uncertain inflation has raised the investment hurdle rate, increasing the likelihood that returns to risky investment projects will not exceed this rate. Inflation uncertainty, therefore, lowers investment by raising the effective discount rate of such projects.

Inflation uncertainty is also thought to affect the level of investment due to the increased cost associated with collecting additional information. Using a Bayesian error-learning model, Cuckierman (1980) explores this idea by considering a risk neutral firm which picks a single investment out of many that are available. Uncertainty enters this formal model as a vector of variables containing taxes, demand for product, prices, cost, and political occurrences. The primary result of this paper is that when uncertainty increases, the firm finds it necessary to delay investment decisions in order to collect more information. An example of such uncertainty would be the need to forecast the relative variation in firm costs and prices over the lifetime of the investment. High and variable rates of inflation create uncertainty regarding the time path of price and cost increases, and this time path can be critical in measuring the discounted present value of the investment. For a given cost of acquiring information an increase in uncertainty makes it profitable to spend resources to analyse investment projects, especially when the cost of reversing such projects is high.

Cuckierman notes that the increased expenditure on information collection does not imply necessarily a permanent decrease in investment. Firms may simply postpone rather than cancel such projects. However, Cuckierman also suggests that if many potential investors perceive increased uncertainty simultaneously, such postponement may be lengthy or indefinite. In other words, a sustained increase in inflation uncertainty may result in a permanent decline in investment expenditure.

Another example of the role of inflation uncertainty is found in tests of a hypothesis proposed by Friedman (1977). In his Nobel lecture, Friedman observed that Phillips curves fitted on recent data for a number of different countries are positively sloped. He explained this finding by citing evidence that the level of the inflation rate and the variability in the inflation rate are positively correlated. An increase in unemployment is associated with an increase in inflation due primarily to the economic problems associated with highly variable anticipations of inflation. The major element in his argument is the idea that increased volatility in the rate if inflation complicates recognition if relative price changes since information is transmitted via absolute prices. Increases in relative price uncertainty introduce frictions in all markets with a subsequent loss in the efficiency of prices as signals for economic activity. The loss of clear market signals results in a period during which markets and institutions adjust to increased uncertainty, leading to a general decline in output and an increase in unemployment.

Empirical substantiation of the relation between inflation uncertainty and reduced output has been offered by Mullineaux (1980) and Blejer and Lieberman (1980). Using the standard deviations of Livingston survey respondents forecasts of inflation as a measure of inflation uncertainty, Mullineaux finds a negative correlation between industrial production and such uncertainty. Blejer and Lieberman also find a negative relation between industrial production and inflation uncertainty, measured by the absolute variation in

several groups of commodity prices over time.
One problem with these results, however, is that we have no indication of the specific sector in which the decline in economic activity would occur. The arguments presented by Malkiel and Cuckierman suggest that inflation uncertainty is negatively related to investment activity, whereas the results presented by Mullineaux indicate that the decline in economic activity could be focused on either the consumption or investment good sectors. The negative relation between inflation uncertainty and industrial production found by Mullineaux could actually mask a more important relationship between such uncertainty and the incentives to invest. A negative relation between inflation uncertainty and investment would certainly explain the result found by Mullineaux, and would correspond more closely with the economic dislocation described by Friedman. Clearly, more work needs to be done to identify the economic relationship between inflation uncertainty, economic activity and investment.

Taken together, the above arguments indicate that an increase in inflation uncertainty will reduce the level of gross investment. Increased hurdle rates, increased costs of acquiring information, relative price uncertainty, and lowered aggregate output all suggest that gross investment should decline. Contradicting these ideas, however, is the empirical work of Wachtel (1977) on the relation between inflation uncertainty and aggregate saving. Wachtel measures inflation uncertainty as the standard deviation on forecasts of inflation made by respondents to Michigan Survey Research Center price surveys. Regressing the quantity of savings per household on real income per household and his measure of price uncertainty, Wachtel finds a significant positive relationship between such uncertainty and saving. An increase in the variability of inflation leads to an increase in the level of real savings per household. This evidence is also supported by a similar analysis made by Juster (1975). The author interprets this finding to indicate a precautionary motive in saving behaviour, suggesting that as households become uncertain about future prices and real income, they save more. In the context of investment, this increase in saving should give rise to a concomitant increase in investment. Investment uncertainty, therefore, may be positively associated with gross investment contradicting the hypothesis offered by Malkiel, Cuckierman, and Friedman.

The result that inflation uncertainty leads to an increase in savings would also explain the results obtained both by Levi and Makin (1979) and Bomberger and Frazer (1981). The purpose of these studies is to provide an additional empirical test of the relationship between nominal interest rates, real interest rates, and inflationary expectations. These authors demonstrate, however, that an important variable missing from all empirical tests of the Fisher hypothesis is inflation uncertainty.

By regressing nominal interest rates against measures of inflationary expectations and inflation uncertainty, the authors find that increases in inflation uncertainty are negatively related to nominal interest rates. In both papers, the measure of inflation uncertainty is taken to be the standard deviation of survey responders to the Livingston Price Surveys published regularly in the Philadelphia Enquirer. Levi and Makin suggest that the negative relation between inflation uncertainty and interest rates is indicative of an underlying negative relationship between capital investment and inflation uncertainty. This hypothesis is not tested. It is important to note, however, that the results obtained in both papers are consistent with the findings of Wachtel. An increase in inflation uncertainty leads to an increase in savings which in turn would have a negative impact on interest rates. Such a relationship would indicate an increase in investment in response to the decline in interest

rates, contrary to Makin and Levi's suggestion.
Because of the contradictory nature of these conclusions it is reasonable to develop a simple test of the hypothesis that inflation has reduced the level of gross investment. This test would serve as additional evidence of the range of possible effects of inflation on investment. By appending a measure of inflation uncertainty to the estimating equation, it would be possible to determine the direction, magnitude, and significance of the effect of inflation uncertainty on investment.

Furthermore because the negative relation between inflation uncertainty and economic activity found by (e.g. Friedman (1977), Mullineaux (1980), Levi and Makin (1980), and Makin(1982)), could actually mask a more important and theoretically correct relationship between such uncertainty and the incentives to invest, an attempt also will be made to link inflation uncertainty and investment through output. This however is analyzed in chapter VIII and the effect of inflation uncertainty on economic activity will be related to the investment equations.

CHAPTER VI

EMPIRICAL METHODOLOGY

The purpose of this chapter is to describe the empirical methodology used to assess the effect of inflation on the level and composition of investment demand. Five elements of this methodology are discussed below: (1) The investment equations, (2) the econometric estimation procedure, (3) construction of after-tax finance rates, (4) construction of tax depreciation variables, and (5) other explanatory variables.

6.1 The Investment Equations

The underlying model used for this study is a variation of the Neoclassical Investment Model. The choice of this specific model of investment is due to the fact that the model is relevant to the problem of quantifying the effects of inflation and historic cost depreciation on investment, primarily for two reasons.

First, because the model is derived from conditions of profit - maximisation by a neoclassical firm, which changes in investment behaviour can be traced to changes in cost. Therefore, it is appropriate to predict, that net and gross investment will react to specific economic conditions, such as inflation, which determine user cost. Thus, the investment demand equation represents a consistent methodology for quantifying the effect of inflation, because the mechanism by which such effects can occur is made explicit.

The second reason is based on the conclusion reached earlier, in the analysis of the user cost in chapter IV. Specifically, it was shown that one cannot assess the effects of inflation on depreciation and investment, without explicit recognition of other important variables in the determination of cost.

Quantitative predictions of the effect of inflation on the level and composition of investment can be made with accuracy only when the effects of the level of tax rates, real interest rates, prices of investment goods, and inflation rates have been accounted for, something which the neoclassical model satisfies.

However, although the standard Neoclassical Investment Model, or some variation of it, has been used extensively in empirical research, the model, as we have discussed in chapter III, is not free of criticisms. Implicit in the simplest version of this model, are a number of very strong assumptions, including homogeneous capital, a putty - putty technology, constant proportional replacement, myopic and risk-neutral decision-making, and a known, exogenous financial mix. The present study, however, accepts these assumptions (with the exemption of a Cobb-Douglas production function) in order to focus on the problem of measuring the effect of inflation in the framework of this popular and influential model.

Evidence from U.S.A., Feldstein (1982), shows, that the traditional implementation of the model, has not given adequate attention to inflation and that any attempt to analyse the recent investment experience, on the basis of that implementation, would be misleading.

The properties of a Cobb-Douglas production function, and the role of technology it implies, make it mathematically convenient for empirical studies. Numerous critics however, seriously question the appropriateness of such an assumption.

Fisher (1971) notes the strong restrictions imposed on the way the cost of capital can enter the investment function with such a production form, and that, results of the standard Neoclassical Investment Model, may depend heavily on these assumptions. Eisner (1979) also questions the theoretical assumption implied by the Cobb-Douglas production function, of a unitary elasticity of substitution. For example, Eisner and Nadiri (1968) and Coen (1969, 1971) obtained estimates closer to zero than to one, thus reducing the neoclassical investment equation to the simple accelerator model, where investment is only determined by the level of output.

Using aggregate UK data, Boatwright and Eaton (1972) estimated the elasticity to lie between 0.4 and 0.7, Jenkinson (1981) found a preferred value of 0.25, while Savage (1977), Bean (1981) and Bosworth (1984) adopted a value of half on practical grounds.

Furthermore, as we have seen in previous chapters, inflation affects the value of the user cost of capital, in two important ways, through the cost of funds, and through the present value of depreciation deductions. Feldstein (1982) adjusted the cost of funds variable (r), to reflect the real net cost of the use of debt, and defined (r) to be a weighted average of debt and equity. Moreover, his formulation recognised, that during a period of inflation, fixed debt will be paid in future depreciated units, thus the real cost will be less than the nominal cost.

Using similar reasoning, the present value of depreciation deductions variable is fixed and declines when the rate of inflation rises. To compensate for this effect, Feldstein (1982) discounted the future depreciation deductions using the nominal cost of funds. The nominal cost of funds used as the discount rate of inflation.

Since inflation was highly present during a portion of the sample time period, the inflation adjustment seems appropriate for this study, and indeed it represents the core of it. A detailed analysis of these adjustments are presented in the later sections of this chapter.

However, another aspect of the relation between inflationary expectations and investment has not received much attention. This problem concerns the effect of inflation uncertainty on investment. A review of recent literature (chapter V) suggests that variations in the probability distribution of inflationary expectations could have real effects on the level and composition of investment. Because of the above therefore, it is reasonable to try and develop a test for the hypothesis, that inflation uncertainty has reduced the level of gross investment. Empirical substantiation of the relation between inflationary uncertainty and investment is achieved through output, which is fully discussed in the next chapter.

Finally, the choice must be made, as to the use of partial equilibrium, as opposed to a general equilibrium analysis. The arguments that a partial equilibrium model fail to consider "feedback", or in direct effects, are not without warrant. However a partial equilibrium approach will yield important information on the direct effect of the variables in question.

The purpose of this study is to view the direct effect of inflation, on the manufacturing investment of the U.K. economy. Accordingly, one could argue, that while the partial model may miss a portion of the entire macroeconomic picture, it would seem reasonable to expect it to capture important relationships of a more direct nature.[1]

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(1) A possible argument against the use of a partial equilibrium model would be that general equilibrium effects might invalidate the results of a partial analysis. Since variations of the SNIM have been employed successfully in many complete model systems (for example, see Green (1980)), it would appear that the basic relationships of the model have general validity.

All the above arguments therefore, have resulted in a variation of the Standard Neoclassical Investment Model (SNIM), that will from now on be referred to as the modified SNIM. The basic model is well-known (see chapter III) and can be summarised briefly.

Each firm has a desired capital stock at each time (K_t^*) and, to the extend that its actual capital falls short of the desired capital, the firm immediately orders capital goods to eliminate the difference. The sum of installed capital and capital on order is thus equal to the desired capital stock at the end of each period. This implies that in each period, the stock of outstanding orders is increased or decreased by exactly the change in the desired capital stock, $K_t^* - K_{t-1}^*$. Since there are delivery delays, the observed net investment can be represented by a distributed lag distribution of these orders:

$$I_t^n = \sum_{j=1}^{N} \omega_j \, (K_{t-j}^* - K_{t-j-1}^*) \qquad (6.1)$$

This specification is based on an implicit assumption about replacement investment. The existing stock decays exponentially at a constant rate d, requiring replacement investment of dK_{t-1} to be made in year t, to maintain the capital stock. Since firms know the delivery lag distribution exactly, they can anticipate the replacement investment that will be required in each future year (up to the length of the longest delivery lag) and can therefore order replacement investment far enough in advance to make exactly the required replacement.

Gross investment is therefore given by:

$$I_t^g = \sum_{j=1}^{N} \omega_j \cdot (K_{t-j}^{*} - K_{t-j-1}^{*}) + dK_{t-1} \qquad (6.2)$$

The current model, however, will employ a constant elasticity of substitution production function (CES) rather than a Cobb-Douglas one, with m factors, which when normalized could be written as:

$$Q = \left(\sum_{i=1}^{N} a_i x_i^{(\sigma-1)/\sigma,\ \sigma/\sigma-1} \right) \qquad (6.3)$$

where Q = output in physical units

x_i = input of the i^{th} factor

σ = the elasticity of substitution assumed constant over time.

a_i = the distribution parameter for the i^{th} factor, assumed constant over time.

If the production function has a constant returns to scale and a constant elasticity of substitution between capital and labour and if capital is completely malleable, then, the original capital stock becomes:(2)

$$K^* = a^{\sigma} \frac{p^{\sigma}}{c} Q \qquad (6.4)$$

where (Q) is output, (p) is the price of that output, (σ) is the elasticity of substitution and (a) is the elasticity of capital with respect to output.

Substituting (6.4) into (6.2) yields:

$$I_t = a^{\sigma} \sum_{j=1}^{N} \omega_j \left[(p/c)^{\sigma}_{t-j}\, Q_{t-j} - (p/c)^{\sigma}_{t-j-1}\, Q_{t-j-1}\right] tdK_{t-1} \qquad (6.5)$$

As before the relative price term p/c is given by the price of output (p) and the user cost of capital (c). The user cost of capital (c) reflects now the real price level for the investment goods pk/py, the real after tax cost of capital ($\bar{r}$), the depreciation rate (d), the corporate tax rate (T), and the real value of depreciation allowances (A).

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(2) For mathematical proof see Eisner and Nadiri (1968)

$$c = \frac{P_k}{P_y} \frac{(\tilde{r}+d)(1-A)}{1-T} \tag{6.6}$$

Calculation of real cost of finance ($\tilde{r}$) and the real value of depreciation allowances (A) are discussed below.

The accelerator model implicitly assumes $\sigma=0$ while the Cobb-Douglas technology, assumed by Jorgenson and collaborators implies $\sigma=1$. In this study, however, a range of values for σ in the interval (0,1) were substituted into the general form of the optimal capital stock equation (6.4), and their results are printed in chapter VIII. A value of (σ) different from unity would imply acceptance of constant elasticity of substitution production function rather than a Cobb-Douglas one.

Two aggregate investment equations are therefore estimated for the U.K. manufacturing sector, one for equipment and one for structures, as well as an aggregate investment equation for a mixed project of equipment and structures. The time period selected for the study was 1963-1986 with quarterly observations being used. Data were generally not available in sufficient detail prior to 1963 to enable extension of the sample period. The use of quarterly, as opposed to annual, observations seemed to be an acceptable approach based upon a review of the investment demand literature.

6.2 The Econometric Estimation Procedure

The model derived from the Standard Neoclassical Investment Model was given at (6.5) above. After restatement of the lag operator and with the inclusion of an inflation uncertainty and error term the resulting estimation equation is written as:

$$I_t=a^{\sigma}\sum_{j=1}^{N}\omega_j\ [(p/c)_t^{\sigma}\ Q_t - (p/c)_{t-1}^{\sigma}\ Q_{t-1}]+dK_{t-1}+\lambda V_t+e_t \tag{6.7}$$

The above specification is applied to quarterly data using regression analysis.

But as it is well known, the estimation of the weights in the distributed lag in the above equation by ordinary least-squares, produces poor results, because of multicollinearity between successive lagged values, of the appropriate independent variable. In order to overcome this problem, the above equation is estimated using the Almon variable technique.

The method developed by Almon (1965) assumes, that the weights of the distributed lag, lie on some polynomial.

It is not possible to estimate all the points on the distribution directly by regression analysis, because of the problem of collinearity j only a few points on the curve are actually included in the estimation procedure, the remainder being computed by Lagrangian interpolation. This allows each of the individual weights to be computed together with an estimated standard error for each. In practice the coefficients are estimated with the help of Time Series Processor (TSP) computer package. The degree of the polynomial and the maximum lag, remain to be specified, so there was considerable scope for experimentation. Also, the polynomial is only used between a predetermined range j outside this range the lag coefficients are specified to be zero, and the polynomial is not employed. However a further possibility, as applied by Almon, is to tie the lag distribution down by requiring the polynomial to give a zero value on either side. But there is no particular reason to do this in general and the evidence is that it tends to unnecessarily restrict the shape of the lag distribution.

The results as to the degree of the polynomial, as well as the maximum lag used for both structures and equipment are presented in chapter VIII.

In the neoclassical theory of investment behaviour with

(CES) production function, changes in desired capital are known only up to a multiplicative constant, the elasticity of output with respect to capital input a^{σ}. The constraint that the sum of the sequence of coefficients ωj is unity[3], may be used to obtain an estimator of this elasticity.

From the estimating equation (6.5) we have estimates of $(a^{\sigma} \sum_{j=0}^{N} \omega_j)$'s and with the requirement that the sum of ω coefficient is equal to one, we obtain $\hat{a}^{\sigma}$.

With the estimator for $\hat{a}^{\sigma}$ it is possible to measure the effect of changes in the inflation rate on gross investment. To assess the effect on gross investment

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(3) As investment projects take time to complete, let ωj be the proportion which takes j periods to complete. Then, of orders placed this period, a proportion ω_0 will be delivered immediately, a proportion ω_1 will be delivered in the next period, ω_2 in the period after that, and so on.

If all orders are delivered (no bankruptcies among suppliers or cancellation) then:

$$\sum_{j=0}^{\infty} \omega_j = 1$$

expenditures of any change in the rate of inflation, the following partial derivative must be evaluated:

$$\frac{dI}{dp^*} = \frac{dI}{dk^*} \frac{dk^*}{dp^*} \qquad (6.8)$$

Suppose that k^* has been constant for some time, but it then change to new level, following a change in the inflation rate.

If k^* increases to a higher level, and subsequently investment occurs to adjust actual k to k^*, then once this is achieved, replacement investment is all that is occurring, and this will be higher than before by a proportion d of the increase in k^*. In other words gross investment will simply equal the amount of replacement investment for the new optimal level of the capital stock. Therefore in the long run:

$$\frac{dI}{dp^*} = d \frac{dk^*}{dp^*} \qquad (6.9)$$

Recall that $k^* = a^\sigma \left[\frac{p}{c^*}\right]^\sigma Q$ where c^* is a function of p^*.

Hence, $\frac{dk^*}{dp^*}$ is given by $\frac{dk^*}{dc^*} \frac{dc^*}{dp^*}$. Differentiating

$$\frac{dk^*}{dc^*} = \frac{- a^\sigma p^\sigma \sigma c^{\sigma-1}}{c^2} Q \qquad (6.10)$$

and

$$\frac{dk^*}{dp^*} = \frac{-(a^\sigma p^\sigma \sigma c^\sigma)}{c^3} Q \cdot \frac{dc^*}{dp^*} \qquad (6.11)$$

Because inflation enters the user cost of capital variable in such a non-linear fashion, estimates of $\frac{dc^*}{dp^*}$ will be obtained by calculating the change in c^* at different levels of inflation.

In summary, the effect of inflation may be calculated on a partial equilibrium basis by evaluating:

$$\frac{dI}{dp^*} = d\,\frac{dk^*}{dp^*} =$$

$$= \frac{-d(a^\sigma p^\sigma \sigma c^\sigma)}{c^3} Q \cdot \frac{dc^*}{dp^*} \qquad (6.12)$$

This can be calculated from an estimate of $\hat{a}^\sigma$ and estimates of the parameters of c^*. Since these values vary, it is necessary to choose a time on which to base the calculation. The results discussed in chapter VIII, calculate the effect of changes in inflation on gross investment, using values which held at the end of the sample period. Calculations are carried out for both the equipment and structures equations, and from these results, predictions of the effect of inflation on the level and composition of investment are made.

6.3 <u>User Cost of Capital - The Cost of Finance (r)</u>

The variable (r) is used in various contexts and with varying definitions. Generally, it represents the rate of return that can be earned on marginal investments, thus it also represents the opportunity costs of funds. Viewing (r) as the opportunity rate of return, a profit maximising firm would use this rate as a measure of the cost of financing alternative investment projects and as the rate for discounting future cash flows. Thus, the terms financing cost, discount rate or rate of return are often used synonymously to define (r).

Economic theory suggests that, in equilibrium, after tax rates of return (r), adjusted for risk and earnings expectations, will be equaled across assets by the market. As noted by Nickell (1978), however, estimates of (r) have varied extensively among investment demand studies. The differences in choice of (r) reflect alternative theories of corporate finance, and varying methods of measurement.

Alternative theories of the financing decisions of firms will result in different measures of (r). If one adopts the Miller - Modiglani (1966) approach, (r) would be defined as a weighted average of the costs of external finance (debt) and internal finance (equity). This approach is employed in numerous studies, such as

Feldstein (1982), Feldstein and Flemming (1971), Bischoff (1971b), Jorgenson and Stevenson (1967). Other studies such as Boatwright and Eaton (1972), Rowely (1972), Coen (1971), Eisner and Nadiri (1968), Bean (1981), Jenkinson (1981), assume that (r) is best represented by the cost of external finance (debt) only.

Additional differences will also result depending on the assumptions of how (r) is measured. Although an equilibrium (r) may exist, observing the appropriate rate may not be possible due to measurement difficulties. Thus, as noted by Bischoff (1971 b), estimates are made of the unobservable true rate (r). Felstein and Flemming (1971) study of investment in equipment and structures approximated (r) as a weighted combination of equity and debenture yields. Boatwright and Eaton (1972) in a study of investment in U.K. manufacturing used the Financial Times dividend yield on industrial ordinary shares, for estimating (r). Jenkinson (1981) in his investment study employed the rate on five year British government stock, in estimating the nominal rate of interest Bean (1981) used the Rate on Bank borrowing taken as two points above Bank rate/Base rate, to estimate the nominal rate of interest (r). Still other studies have simply assumed a constant value of before-tax (r). Thus, there exists a plethora of methods for estimating the parameter (r).

Due to the controversy surrounding the discount rate (the solution of which is beyond the scope of this study), and the lack of strong reasons for selecting a particular method or concept of measurement, this study will employ alternative estimates of (r).
The calculations of (r) will be made both with and without the internal finance (equity) variable, and will rely on market determined interest rates as estimates of the external finance (debt) variable.

This approach to dealing with the controversy surrounding (r) has been used by other authors, such as Hendershott and Hu (1981).

Despite the above however, a bigger weight will be given in incorporating the effects of inflation in estimating (r).

6.3.1 Real Versus Nominal After - Tax Finance Rates

The nominal after tax financing rate used to discount cash flows by most researchers especially in U.S.A. is a weighted combination of equity and debt specified as:

$$r = bi(1-T) + (1-b)e \qquad (6.13)$$

where b = portion of investment which is debt - financed.

e = nominal after-tax return to equity

i = nominal rate on corporate debt.

r = nominal after-tax weighted average cost of capital.

T = tax rate.

The after-tax return to equity or cost of equity (e), is usually estimated as the ratio of nominal earnings per share to stock prices per share. This conventional earnings-price ratio however can be misleading, when there is inflation, since it is based on book earnings rather than real economic earnings. Book earnings overstate real earnings by using historic cost depreciation and some FIFO inventory accounting, but also understate real earnings by excluding the real reduction in the value of outstanding debt that occurs because of inflation.

Previous researchers [Ando, Modigliani, Rasche, and Turnovsky (1973), Clark (1979)] have calculated real after-tax finance rates by employing the following formulation:

$$\tilde{r} = (1-T)\, b\, (i-p^{*}) + (1-b)\tilde{e} \qquad (6.14)$$

where $\tilde{r}$ = real weighted average cost of capital

$\tilde{e}$ = real after-tax cost of equity finance

p^* = expected inflation rate.

Note, however, that expression (6.14) does not properly specify the tax deductibility of nominal interest payments in the calculation of taxable income. Firms do not calculate interest deductions on the basis of real interest rates, but rather on nominal interest rates. The correct specification should be:

$$\tilde{r} = b\ [(1-T)i - p^*) + (1-b)\tilde{e} \qquad (6.15)$$

Reflecting the fact that real cost debt of debt finance is reduced first by the deduction of nominal interest payments and then, secondly by the decline in the real value of the outstanding debt separate from the taxation question. This interpretation is implicit in the calculation of the real after - tax weighted finance rates employed by Hendershott (1981) and Feldstein, Green, and Sheshinski (1978). The procedure for the calculation of such rates is described below, beginning with discussion of the real cost of equity finance $\tilde{e}$.

The real after - tax rate of return on corporate equity issued to finance the investment is:

$$\tilde{e} = e - p =$$

$$= [(1-T)(Y-dP_k - iD) - T\ (d-d^*)\ P_k + p^*D]/E \quad (6.16)$$

where D = debt issued to finance the investment

E = equity issued to finance the investment

d = economic depreciation rate

d^* = tax depreciation rate

Y = operating income net of operating costs

P_k = the market price of capital.

The terms inside the brackets represent real earnings after - tax adjusted to include:

(1) real income accruing to the excess of tax depreciation deductions over economic depreciation, and

(2) the real gains accruing to share holders from the expected erosion in the real value of the debt issued measured by p^*D.

In general, the expected real earnings accruing to equity holders from a new investment are the sum of expected after - tax operating earnings (EAT), plus the expected erosion in the market value of the debt (p^*D). The rate of return to such equity, therefore, may be specified as:

$$\tilde{e} = (EAT + p^*D)/E \qquad (6.17)$$

Assuming that D=bRA and E=(1-b)RA, where RA is investment in real assets then:

$$\tilde{e} = \frac{EAT}{E} + \left[\frac{b}{1-b}\right] p^* \qquad (6.18)$$

Substituting $\tilde{e}$ into expression (6.15), it is possible to solve for the real after - tax weighted cost of finance. Thus:

$$\tilde{r} = b\,[(1-T)i - p^*] + (1-b)\left[\frac{EAT}{E} + \left[\frac{b}{1-b}\right] p^*\right]$$

$$= b(1-T)i + (1-b)\frac{EAT}{E} + bp^* - bp^*$$

$$= b(1-T)i + (1-b)\frac{EAT}{E} \qquad (6.19)$$

The decline in the real cost of debt due to inflation, therefore, is accounted for in the real return to equity (EAT/E). Of importance also is the fact that calculation of the real after - tax finance rate is independent of the proxy chosen for the expected inflation rate. Nominal discount rates used in the calculation of the present value of depreciation deductions must be constructed simply by adding the expected inflation rate to $\tilde{r}$ or

$$r = \tilde{r} + p^* \qquad (6.20)$$

With the above theoretical derivation of the nominal discount rate, it is possible to make specific predictions of the effect of inflation on the level and composition of investment. A change in p^* results in a change in the discounted present value of tax depreciation deductions and the user cost of capital will change accordingly.

Predictions of the effect on gross investment may be calculated according to the approach described in an earlier chapter.

Recent literature on the effects of inflation on corporate behaviour indicates, that changes in inflation, may affect firms optimal mix of debt and equity finance. This issue is significant because it affects the parameter b used to calculate the real and nominal finance rates discussed above.

Using a general equilibrium monetary growth model, Feldstein, Green, and Sheshinski (1978) analyse the effect of inflation on the optimal debt - equity mix both from the standpoint of the firm and the willingness of the financial markets to absorb the financial investments. Firms are assumed to engage in financial cost - minimisation, optimising the mix of debt and equity finance given known costs of employing both instruments.

Likewise, buyers of these instruments are assumed to measure the after - tax returns to owning the debt versus equity, incorporating information on differential capital gains and personal tax rates. Given the above parameters, the authors compute the derivative of the optimal debt equity ratio with respect to a change in the inflation rate. Unfortunately, this derivative turns out to be dependent on assumed magnitudes for various corporate and personal tax rates. The authors however, assert that the sign of the derivative is positive, basing their conclusion on estimates of the important tax parameters.

A positive sign for this derivative indicates that firms will increase the ratio of debt to equity finance, given an increase in inflation.

In economic terms this can be described with reference both to the behaviour of business firms and personal investors given the change in inflation. At the corporate level, an increase in the inflation rate, leads to an increase in the nominal interest costs, associated with issuance of new debt. Under the tax law, however, nominal interest payments are deductible for purposes of calculation of tax liability. Because firms can deduct the inflationary increase in the cost of debt finance, but not the inflationary increase in equity finance, firms are encouraged to finance new projects by issuing new debt. Equity owners of the firm encourage such a move because the expected decline in the real value of new debt issue due to inflation, would represent a capital gain to the stockholders.

Feldstein, Green and Sheshinski note, however, that inflationary increases in nominal interest payments received by holders on the new debt are not deductible under personal tax laws, indicating, that the shareholders will suffer a real capital loss due to inflation.

In total, the effect of inflation on the debt - equity ratio will depend on the relative corporate and personal (interest and capital gains) tax rates experienced by the market participants. Based on their estimates of these tax rates, the authors assert that the above derivative is positive, although precise estimation of the effect on the debt - equity ratio is impossible due to the importance of unobservable tax rates.

Auerbach (1981) obtained the same result using a similar methodology and further points out that it is critical to analyse the relative movements in real cost of debt and equity finance, before one can isolate the effects of inflation on the debt - equity ratio. Gordon (1979) also finds that inflation increases the debt - equity ratio, although he further qualifies his analysis by noting, that increased cost of bankruptcy associated with higher debt - equity ratios, further limits the firms ability to increase the debt proportion.

Von Furstenburg (1979) has computed an empirical measure of the debt - equity ratio for the period 1952 to 1978. His analysis indicates that the aggregate debt - equity ratio has increased from .185 in 1953 to .292 in 1978. Although the estimated change in this ratio over the period would correspond to a concurrent increase in inflation, it is impossible to isolate the cause of the increase.

Clearly all the above studies indicate that there is a positive relationship between inflation and the debt - equity ratio. Precise estimation of the effect however is impossible due to the unobservable tax rates facing the shareholders as suggested by Feldstein, Green and Sheshinski (1978). For this reason no attempt is made to measure the quantitive effect of inflation on debt - equity ratio, although we recognise the positive effect.

Therefore our estimates are extracted from actual published figures produced by the Central Statistic Office (CSO).

Calculation of the real and nominal discount rates requires specification of proxies for each of the variables discussed above. (equation 6.19). For (i), the nominal rate of interest, the rate on five - year British government stock is employed, and for (T) the tax rate, the corporation tax has been used.

The term (EAT/E) is measured as after-tax profits of industrial and commercial companies, minus:

(1) the stock appreciation adjustment, which eliminates inventory capital gains and
(2) the capital consumption adjustment, which

eliminates fictitious profits from the conversion of tax depreciation allowances to replacement cost depreciation.

The market value of ordinary shares is obtained by dividing dividends on ordinary shares by the dividend yield on industrial (500 shares).

The exact method of calculating the cost of equity at time t is given by the following algebraic formulations:

$$\text{COST OF EQUITY} = \frac{\text{EAT}}{\text{MARKET VALUE OF ORDINARY SHARES (MVS)}} \tag{6.21}$$

where EAT = GTP + R - CCR - SA - TAXES - INTEREST and

$$\text{MVS} = \frac{\text{DIVIDENDS ON COMMON STOCK (QUARTERLY ANNUALISED)}}{\text{DIVIDEND YIELD [INDUSTRIAL (500 SHARES)]}} \tag{6.22}$$

Therefore the real after tax cost of equity is:

$$\frac{\text{GTP} + \text{R} - \text{CCR} - \text{SA} - \text{TAXES} - \text{INTEREST}}{\text{MVS}} \tag{6.23}$$

where : EAT = Expected after - tax operating earnings

GTP = Gross trading profits

R = Rent received by companies

CCR = Capital consumption at replacement cost

SA = Stock appreciation

Data available for the estimation of the above ratio for manufacturing, were not available, but since about 70% of the industrial and commercial companies consists of manufacturing companies, the result was thought to be a good proxy for manufacturing. The above data were taken from various issues of Economic Trends and Financial Statistics published by the Central Statistic Office.

Investment is no doubt more commonly assessed by comparing expected rates of return to the cost of capital, but to estimate each of those separately requires satisfactory measures of expectations. In the methods used above to estimate the cost of capital, this problem is tackled by assuming that future real earnings, from the existing physical capital, will be the same as current real earnings. As earnings in any one year may be influenced by many factors, this assumption is not likely to be very realistic. However, the problem of measuring expected future earnings may be unimportant as far as influences on investment are concerned if, the incentive to invest is related to the ratio of prospective profitability to the cost of capital.

Both of these items are ratios with expected profits in the numerator, so that any error resulting from the use of current profits as a measure of future profits affects each item in the same proportion.

6.4 User Cost of Capital - The (A) Variable

Measurement of the user cost of capital for both equipment and structures requires specification of the present value of tax depreciation deductions as input to the user cost formula (6.6). Calculations of these values in turn requires specification on tax depreciation method and allowable depreciation lifetimes.

This section describes the methodology and assumptions employed in these calculations adopted by Mellis and Richardson (1976).

Investment incentives have taken a number of forms in Britain each of which will be considered in turn. The most basic is the annual depreciation allowance, d, which firms are permitted to set as a cost against their taxable income. Apart from the above, however, there have been three principal types of investment incentive in Britain. First, the "investment allowance" permitted firms to write off some proportion of the purchase price of a new asset against tax, without affecting any subsequent claims to depreciation allowances.

Second the "initial allowance" permitted firms to write off a higher proportion of the asset's value in the first year, but at the cost of being allowed a correspondingly lower proportion in subsequent years.

These two allowances co-existed until 1966, when they were abolished, in favour of the "investment grant", under which the government in effect paid a proportion of the price of a new asset. The value of investment grants to firms was lessened by the fact that depreciation allowances could only be claimed on the cost of the asset, less the grant. Investment grants in turn were abolished in 1970 when "initial allowances", though not "investment allowance", returned. The actual rates of incentive varied in quite complex ways, first according to the nature of the assets, plant and machinery being treated move generously than industrial buildings, second according to location, development areas receiving preferential treatment.

The individual rates were also changed quite frequently, as were the rates of tax on companies, which affected the value of the incentives.

For tax purposes depreciation on plant and machinery expenditure is on a reducing balance basis.

Following basically the same approach of Mellis and Richardson (1976) the net present value per unit of capital cost over an asset life of N years is given by:

$$NPV = \frac{T}{(1+r)^L} \left[(v+R+d) + \frac{d(1-d-R)}{1+r} + \frac{d(1-d)(1-d-R)}{(1+r)^2} + \ldots \right] \tag{6.24}$$

$$= \frac{T}{(1+r)^L} \left[(v+R+d) + \frac{d(1-d-R)}{1+r} \sum_{i=0}^{N} \left[\frac{1-d}{1+r} \right]^i \right] \tag{6.25}$$

where N is infinite this equals:

$$= \frac{T}{(1+r)^L} \left[(v+R+d) + \frac{d(1-d-R)}{r+d} \right] \tag{6.26}$$

where T = tax rate

R = initial allowance

v = investment allowance

d = Statutory annual reducing balance writing down allowance (constant percentage of the balance outstanding at the end of each year)

r = rate of discount ($\tilde{r} + p^*$)

L = lag in tax payment (1.75 years)

From 1966 to 1970 investment grants were in operation, both nationally and regionally, for plant and machinery. The capital, available to offset against corporation tax, was correspondingly reduced by the value of the investment grants. The present value of incentives under this scheme is given by:

$$NPV = \frac{G}{(1+r)^g} + \frac{T}{(1+r)^L}\left[d(1-G) + \frac{d(1-G)(1-d)}{1+r} + \ldots\right] \qquad (6.27)$$

$$= \frac{G}{(1+r)^g} + \frac{T}{(1+r)^L} \cdot d\,\frac{(1-G)}{(r+d)} \qquad (6.28)$$

where G = investment grant (percentage of capital costs)

g = grant payment lag (.5 years)

The White Paper of October 1970 reintroduced a system, based on initial allowances.

For industrial buildings depreciation is calculated on a straight line basis. The formula, using the same general notation as for reducing balance calculations for the present value of allowances, is given by :

$$NPV = \frac{T}{(1+r)^L}\left[(v+R+d) + d\left[\frac{(1+r)^N-1}{r(1+r)^N}\right]\right] \qquad (6.29)$$

$$\text{where } N = \left[\frac{1-R-d}{d} \right] \tag{6.30}$$

and d is now the annual straight line allowance in each year, a fixed percentage of the original capital sum. This formula has been applicable to expenditure on industrial building nationally throughout the period. The full details of the variables used in calculation are set out in tables 1 to 4 of Mellis and Richardson (1976), which give the tax rates, the rates of grants and allowances for machinery and industrial buildings.

The present value of capital allowances (A) for a mixed project is computed as a weighed average of the above equations on the basis of the relative proportion of investment in plant and machinery.

The resulting (A's) were calculates with the use of Minitab Computer package using alternative measures of (r), as suggested in the previous section.

In evaluating the various schemes and rates of incentive that have been in operation, the general strategy has been to consider the expected value offered, rather than the actual benefit received. This has the advantage of being in line with the spirit of investment appraisal and avoids the very considerable problems of evaluation on any other basis.

Thus, it is assumed that a particular scheme will operate unchanged throughout the life of the asset. The value of the incentive to the firm has been calculated in discounted cash flow terms, for both types of asset.

However, one may object on the grounds that at least for most of the period under review the typical firm was not using DCF investment appraisal methods. However, a consistent set of criteria is required to make comparisons and the assumption that firms behave optimally requires that a DCF method be used.

The financial position of a firm is important in so far as it determines the firms ability to take full advantage of available allowances, at the earliest possible occasion. The present value of any tax allowance on capital expenditure will vary, according to the level of gross company income, currently available for tax purposes.

Thus, a firm with a current gross income equal to or in excess of available allowances will, in a given year, be able to take full and immediate advantage of them, the so called "full tax" case. One with gross income less than the available allowances may obtain the full allowance, but subject to some distributed lag time delays.

Hence, for a given incentive scheme, there are an unlimited number of alternative valuations depending on the time profile of gross company income, relative to that of available allowances, ranging from the "full tax" case, to the "no tax" case, where a firm has accumulated sufficient allowances to entirely offer all future tax payments.

In the above calculations and in line with previous studies, it has been assumed that all companies are paying tax in full and are thus eligible for the various investment incentives, available at the time. The results, however, obtained by the tax model by Levi and Morgan (1985) demonstrate the weakness of such an assumption. To evaluate the potential impact of tax exhaustion on investment behaviour, the modified Neoclassical investment Model was run again, using an average effective corporation tax rate. This rate was calculated by the ratio of taxes paid by the manufacturing sector over pre-tax profits, adjusted for north sea oil income, which is trading profits plus other income, minus depreciation, minus interest paid. All the relevant data for the computation of the average effective tax rate were extracted from CSO tapes and their results are presented in chapter VIII.

6.5 Other Explanatory Variables

An estimate of the expected inflation (P^*) is required in equation (6.20) to construct the nominal after tax finance rate. Several models for forecasting inflation are suggested in the literature. For example Bodie (1976), Jaffe and Mandelker (1976), Nelson (1976) and Linter (1973) have used past inflation rates as surrogates for expected inflation rates. Fama (1975) develops an interest rate model, in which expected real returns on treasury bills are constant over time. Nelson and Schwert (1977) show, that inflation forecasts from a univariate ARIMA model, are about as reliable as those from Fama's treasury bill rate model. Fama (1981) suggests using variables such as the growth of the money supply and the growth rate of industrial production, in addition to lagged inflation and interest rate, to estimate expected inflation.

Therefore as we can see there exists a plethora of different inflationary forecasts, the comparison of which is beyond the scope of this thesis. For a summary and comparison of inflation forecasts, see Fama and Gibbons (1982). Nevertheless to see whether our results are affected by different forecasts of inflation, two different estimates are employed. Firstly, expectations are approximated by a distributed lag on actual consumer price index, and secondly an expected series is achieved, through an Arima model (For the inflation uncertainty variable uncertainty was measured with the standard deviation of expected inflation forecasts for a two year horizon).

Estimation of the equation requires computation of optimal capital stock measures, for both equipment and structures. As described in section 1, calculation of this variable is based on the following formula:

$$K^{*} = a^{\sigma} \frac{P^{\sigma}}{C} Q$$

for both equipment and structures, where:

$$C^{*}_{EorS} = \frac{P_k}{P_y} \frac{(\tilde{r}+ d)(1 - A)}{1 - T} \qquad (6.31)$$

where P_k/P_y = real price level for investment goods

$\tilde{r}$ = real after-tax cost of capital

d = economic depreciation rate

A = real value of depreciation allowances

T = corporation tax

The price deflator for output is represented by the Gross National Product Deflator and secondly, by the

Total Final Expenditure, both of which are at 1980 base and obtained from Economic Trends. The reason for adopting two different deflators for output was to show whether the results were sensitive or not to such a change.

For output, data represents index numbers for the Total Manufacturing Industries at 1980 base and seasonally adjusted and once again, the data were obtained from Economic Trends, published by the CSO.

Calculation of the real cost of finance ($\bar{r}$) and real value of depreciation deductions (A), was discussed in the previous sections. The real price of equipment is calculated using the ratio of the price deflators for capital equipment and Gross National Product, at 1980 prices and seasonally adjusted.

A similar calculation is performed to construct the real price of structures. The economic depreciation rate (d), however, is derived through the estimation of the actual capital stock series, which, as we have seen, is one of the determinants of investment, in the Neoclassical Investment Model.

Replacement investment is hypothesised to be a constant proportion of the capital stock, at the beginning of the period. This is expressed as:

$$RI = \delta K_{t-1} \tag{6.32}$$

where RI is replacement investment and δ is the rate of depreciation. However, this form implicitly assumes that the capital stock grows at a constant rate, an assumption which is less plausible in the short-run than in the long run. Indeed, as Feldstein and Foot (1970) point out, this does not imply rejection of the following hypothesis: "Replacement investment varies around some average non-zero level in a way which is systematically related to other short-run economic prices".

The use of this specification, however, involves the problem of the measurement of capital stock. Data on the size of the capital stock in the U.K. on quarterly basis do not exist. Thus, it is necessary to compute stock figures using the quarterly investment flows, built on to a base year stock figure.

An exponential depreciation pattern was chosen of the form:

$$K_t = I_t + (1 - d)K_{t-1} \tag{6.33}$$

where K_t and K_{t-1} are net capital stock at the end of the current and preceding periods respectively, I_t is gross investment and d is the rate of depreciation.

Several capital stock series were calculated for different values of d with the use of Time Series Processor (TSP) package.

A figure of 6 % for the assumed depreciation rate was chosen for equipment as well as for the aggregate equation and 4 % for the structures. The reason for that was that at these depreciation rates the constructed quarterly capital stock series were quite close to the annual ones. Some researchers, however, adopt a procedure where they choose the value of P for which the estimated coefficient of the capital stock series, δ, and the assumed depreciation rate, P, are equal. With this procedure, however, they impose a capital stock series to the model which might not be correct.

Finally, the dependent variable, Investment (I), represent gross investment expenditure in manufacturing at 1980 constant prices and seasonally adjusted for equipment, structures and aggregate level. The source of data on investment were taken from the Economic Trends, published by the CSO.

The data resulting from the previous estimations provide the sample information and data base necessary for applying the investment equations. The results of the model application are presented in chapter VIII.

CHAPTER VII

INFLATION UNCERTAINTY ECONOMIC ACTIVITY AND INVESTMENT

With the acceleration of the inflationary process the study of the real effects of inflation whether anticipated or unanticipated has attracted a great deal of attention. Less effort has ever been directed to the analysis of the effects of inflation uncertainty on investment. We concluded chapter V by proposing a simple test of the hypothesis, that inflation uncertainty has reduced the level of gross investment, by appending a measure of inflation uncertainty to the estimating investment equation. However as we have seen previous research suggests that increased inflation uncertainty reduces output a proxy for economic activity (e.g. Friedman (1977), Mullineaux (1980), Levi and Makin (1980), and Makin (1982)). The negative relation between inflation uncertainty and economic activity found by the above studies could actually mask a more important and theoretically correct relationship between such uncertainty and the incentives to invest.

Therefore in this chapter an attempt will be made to link inflation uncertainty and investment indirectly through output. Towards that the natural rate hypothesis is employed.

7.1 <u>From the Phillips Curve to the Lucas Supply Curve</u>

The Phillips curve associates a low unemployment rate with a high rate of inflation (and vice versa).It implies that the relationship between these two variables is essentially stable over time, and independent of economic policy measures.

The natural rate of unemployment hypothesis postulates the existence of a relationship, stable over time, between the unemployment rate and the difference between actual and anticipated rates of inflation. One of the formulations of this hypothesis is known as Lucas supply curve:

$$U_t = a_0 + a_1(P_t - P_t^*) + a_2U_{nt} \qquad (7.1)$$

where U_t = rate of unemployment

U_{nt} = natural rate of unemployment

P_t = actual rate of inflation

P_t^* = expected rate of inflation

Alternative versions of this relationship are expressed in terms of price levels and not of inflation rates. R. Lucas (1973) himself conducts his theoretical analysis in terms of price levels.

The Keynesian macromodels developed in the 1960's and 1950's deal mostly with the problem of aggregate demand and output determination, and tend to neglect the analysis of inflation. This neglect does not reduce at first, the validity of these models, since the inflationary pressures associated with the Second World War subsided rapidly in most industrialized countries.

In the second half of the 1960's renewed inflationary pressures are such that it is no longer possible to exclude the analysis of inflation from macroeconomic models (assuming that full employment is compatible with stable prices). Faced with these developments, Keynesian macroeconomic theorists emphasize the role of the Phillips curve. It provides a theory of inflation which can be integrated into the IS-LM framework of the "neoclassical synthesis" of the Keynesian model.

The theoretical justification of the Phillips curve can be found in a series of studies analysing the process of inflation, set forth in the 1940's and in 1950's. It is generally believed that beyond full employment any increase in aggregate demand brings about price increases only. A wage-price spiral is assumed to come into operation when aggregate demand is positive at full employment. In the neighbourhood of full employment wages are strongly correlated with prices, and at levels of activity below full employment wages tend to be related to the rate of unemployment. Indeed research in prewar business cycles leads to the conclusion that there has been a negative correlation between rates of change of wages and the unemployment rate.

It is assumed therefore that, because of frictions and of bottlenecks, price increases will occur before full employment is reached. These frictional elements are at a further stage, assumed to be stable, at least in the short run, and to depend on structural characteristics of the economy. They give rise to the stable Phillips curve relationships included in Keynesian macroeconometric models.

An increase in employment can be obtained at the expense of higher prices. A justification can thus be found not only for Government interventionism, but also for a state of permanent (mild) inflation, since it will be possible by means of fine tuning polices to reduce unemployment at the expense of a moderate rate of inflation.

Seen from the point of view of the labour market, the Phillips curve may be interpreted as a functional relationship. Indeed, since nominal wages (and costs) are generally rigid downwards, real wage adjustments necessary to ensure an increase in employment, could be obtained in an indirect way, by means of a price increase (due possibly to an increase in money supply) because of money illusion of suppliers of labour.

M. Friedman (1968), who considers the Phillips curve a relationship describing the wage bargaining process, points out that it will not be possible to fool economic agents all the time. Eventually workers will bargain for real wage, aware of inflation. As a consequence the natural rate of unemployment will not depend upon the inflation rate. Any unemployment wages (prices) trade-off is a short-run phenomenon, due to the fact that inflationary expectations have not been adjusted in time to the effective rate of inflation.

From the late 1960's early 1970's onwards, there came to be a convergence of opinions, as to the existence of a long-run endogenous "natural" rate of unemployment to which the economy would eventually converge, independently of economic policy stimuli. The debate then shifted to the relevance over time of money illusion. It focused on whether it would be possible to raise prices so rapidly, by economic policy measures so as to bring about a fall in real wages and thus an increase in employment and real income.

It became therefore necessary to investigate the expectations formation process and to provide a more accurate and general microeconomic interpretation of the natural rate of unemployment hypothesis.

Drawing a distinction between money illusion and errors in the formation of expectations may prove difficult in the real world. If money illusion is not relevant, only errors in the formation of expectations can bring about deviations of employment and output from their "natural" values.

The microeconomic problem is that of explaining why coefficient a_1 in equation (7.1) is negative i.e. why expectations about price increases that underestimate the actual price increases bring about reductions in the unemployment rate (below the natural rate), and vice versa.

Following M. Friedman (1968, 1975, 1976) this result takes place if an increase in the rate of inflation (not perfectly anticipated) brings about asymmetric shifts of the labour supply and demand curves in the real wage- employment space, a temporary reduction in real wages, and an increase in employment. In his 1968 paper M. Friedman suggests, as possible explanation of the negative sign of the a_1 coefficient, asymmetric perception of prices and thus asymmetric formation of expectations. Workers perceive inflation more slowly (and thus with less accuracy) than firms. When the rate of inflation rises, workers readjust their nominal wage demands gradually, and firms exploit their own temporary advantage (of which they are aware), by employing more workers at lower real wages. Workers' expectations are incorrect at first whereas firm's expectations are correct from the outset.

The Natural Rate of Unemployment model, developed by M. Friedman in the labour market, has been transferred on the goods market. The hypothesis is made that the rate of change of output is as good an indicator of economic activity as the unemployment rate. (Equilibrium is assumed to hold simultaneously in the labour and goods market).

We obtain , as a consequence:

$$Q_t = a + \gamma \, (P_t - P_t^*) + \beta Y_{nt} \qquad (7.2)$$

where Q_t = rate of change of output

Y_{nt} = normal rate of change of output

P_t = rate of change of prices

P_t^* = expected rate of change of prices

This relationship has been reinterpreted directly, on the basis of a more general rationale, valid for all kinds of products by R. Lucas (1973, 1975) and is known as Lucas supply curve.

Lucas assumes that production and exchange take place at different locations and that individual agents are not able to distinguish with accuracy between the general and the local (i.e. relative) components of the price of a given product in their own location. Therefore there is confusion between local and global information. Aggregating over all individuals we obtain a relationship analogous to equation (7.1).

The positive sign of coefficient γ is due to the fact that economic agents mistake on increase in the general price level for the increase of the price of the good they supply, increase to which they react by producing more. The higher the frequency of general price level fluctuations, due, for example to monetary disturbances, the larger the probability of conclusion by economic agents between absolute and relative price level fluctuations, with subsequent mistakes in the allocation of resources.

7.2 Inflation Uncertainty and the Phillips Curve

The effect of inflation on labour markets, particularly the level and cyclical movements of the rate of unemployment as we have seen has been a subject of intensive study during the last twenty years. A large part of the theoretical and empirical studies have evolved along the lines suggested by the natural-rate hypothesis, as developed by Phelps (1967, 1970) and Friedman (1968), among others. The essence of the hypothesis is that a distinction should be made between the long-run and the short-run effects of unanticipated changes in aggregate nominal demand. In other words there would be only a short-run trade off, since in a sustained inflation, expectations would become "correct" when ($P_t = P_t^*$) in equation (7.1), and as a consequence we would return to the normal rate.

In his Nobel lecture, Friedman (1977) observed that in recent years higher inflation has often been accompanied by higher not lower unemployment, especially for periods of several years in length. The years that have passed since this observation, have yielded additional evidence in support of Friedman's hypothesis which states, that a positively sloped Phillips curve, may occur as a transitional phenomenon, which will disappear as economic agents adjust their expectations, institutional and political arrangements to a new reality. The explanation suggested by Friedman

(1977) regarding a systematic departure from the condition required for a vertical Phillips curve, is that the higher the average inflation rate, the more variable is likely to be. With increased variability, an additional element of uncertainty is added to every market transaction or arrangement. Full indexation cannot be achieved since not all the necessary price indices are available. Others are available only with lags and are applied to Contract terms only with a further lag. Hence, it is unlikely that indexation would fully alleviate the effects of inflation on real variables.

Therefore Friedman (1977) is arguing that :

(1) higher rates of inflation have been associated with higher variability of the rate of inflation, and

(2) that due to institutional rigidies higher variability in the rate of inflation has produced a reduction in the efficiency of the price system in guiding economic activity and a consequent reduction in output.

From these two components of Friedman's argument we have that high inflation, accompanied by high variability of inflation, will mean a low output. The low output could mean high or low unemployment. If the effect is high unemployment, we have an upward sloping Phillips curve that relates the level of inflation to unemployment.

But these are not the only testable hypothesis he proposes. He also suggests that, (1) the effect of an increase in the volatility of inflation is a transitory one, and (2) though the effect is temporary it is lengthy in terms of chronological time. Friedman notes that "such a transition period may well extend over decades". However, in the "long long-run" the natural rate remains independent of monetary phenomena.

To recap the chain of reasoning in Friedman's analysis runs as follows: Increases in inflation volatility introduce additional frictions in all markets; these frictions reduce efficiency and create incentives for changes in institutions; once the institutions are in place and functioning, the economy again settles down to a natural rate determined solely by "real" factors.

Friedman's view that the natural rate is only temporarily affected by inflation volatility conflicts with recent analysis of Azariadis (1977) who suggests there is a permanent relationship between volatility and unemployment. Unlike Friedman, Azariadis challenges the logical foundation of "natural-rate theory". He argues that "the Friedman - Phelps - Lucas formulation is a special case of a more general theory which obtains only when there exists a complete set of markets wherein private agents can insure against any contigency, including the risk of fluctuations in aggregate real incomes. In reality, however, markets are incomplete and some employers sell insurance to employees through implicit labour contracts".

In such a world Azariadis argues that the variability of monetary phenomena such as money-supply growth (and by extension, the variability of inflation) are related (permanently) to the average level of unemployment.

Given the nature of Friedman's proposition it would require a significant long-time series on unemployment and inflation volatility to test the hypothesis that volatility does not matter in the long-run. However even if neither hypothesis is rejected the data may provide some information on the nature and magnitude of the effect over time periods of interest to macroeconomists.

7.3 Inflation and Price Variability

In discussing the relationship between inflation and price variability it is useful to distinguish two types of price volatility: relative price variability, and the variability of the general price level over time.

Okun (1971) was among the first to note that higher rates of inflation are associated with higher variability of the aggregate inflation rate over time. This result was also found by Logue and Willet (1976), Foster (1976) and Taylor (1981) for time-series and international cross-sections. Taylor (1981) concludes that there is a systematic tendency for periods of high average inflation to be characterized by high variability of the aggregate inflation rate and high uncertainty about future rates of inflation. Uncertainty is interpreted by Taylor as related to the forecast error in time series of actual and expected rates of inflation. Cuckierman and Wachtel (1979) found empirical support for a positive relationship between the variance of inflationary expectations and the variability of inflationary expectations across individuals as forecast uncertainty.

For our purposes, the relation between variability of the rate of inflation and uncertainty regarding future inflation rates is crucial since it is our hypotheses that the extent to which inflation can be fully anticipated bears strongly on its real effects. Thus, based on the various studies mentioned above, it seems plausible to assume that the past two or three decades which were periods of relatively high rates of inflation by historical standards also were characterized by increasing uncertainty regarding future rates of inflation.

The impact of high inflation rates and inflationary uncertainty on real variables is determined to a large extent by institutional arrangements. The institutional setting prevailing in all western societies particularly the almost non-existence of indexation arrangements, suggests that both inflation and inflationary uncertainty might have an impact on real variables.

The relationship between changes in the average rate of aggregate inflation and relative price variability has also been an area of extensive research in recent years. Jaffe and Kleiman (1975), and Vining and Elwertowski (1976) found a positive and significant correlation between relative price variability and inflation rates. The results of Parks (1978) suggest that relative price variability is strongly associated with overall inflation variance, but there is also some evidence supporting a separate effect for the rate of inflation.

Cuckierman and Wachtel (1982) report empirical results which confirm the hypothesis that there is a positive relationship between the variance of inflationary expectations and the variance of relative price change. In interpreting his results Packs (1978) suggested that large variance may be associated with unanticipated change in the rate of inflation. Cuckierman and Wachtel (1982) assumed that uncertainty is related to the variance of inflationary expectations across individuals. Hence their results are also consistent with Park's hypothesis.

Fischer (1981) concludes that his results and the results of other studies support the proposition that the variability of relative prices is positively associated with both expected and unexpected inflation. However, he maintains that it is not entirely clear whether inflation can be thought of as causing the relative price variability. Taylor's (1981) results suggest that there is a strong correlation between relative price dispertion and the variability of the aggregate inflation rate, but not between relative price dispersion and the average level of inflation. He suggests that supply shocks which increased relative price variability combined with accommodating macroeconomic policies aimed at minimising the fluctuations in real output and employment brought forth concurrent fluctuations in inflation rates.

The different results regarding the interrelationship between relative price variability and the variability and the rate of the average price level may be largely attributable to the use of different data sets used in the various studies. However, what has certainly been documented by all studies is the evidence that the inflationary circumstances prevailing in recent periods were accompanied by increasing variability of relative prices. Relative price variability might have economic costs if the variability was largely the result of signal distorting noise. The true signals in relative price movements can be viewed as benefits for the efficient operation of the market mechanism. The increased variability of relative prices which is associated with higher inflation rates and/or higher variability of the rate of inflation might lead to inefficiencies in the allocation of resources. This occurs if the variability of relative prices reflects information confusion rather than an appropriate response to real disturbances that happen to be accompanied by inflation.

Finally, inflationary variability has been found to have repercussions with regard to institutional arrangements. Bordo's (1980) study suggests that contract length varies inversely with relative price variability. Fischer and Modigliani (1978) argue that the effects of increased uncertainty about the rate of inflation is the shortening of contracts and that it should also lead toward the use of indexed contracts.

In the next section we focus on the likely effects of uncertainty regarding future inflation rates on the investment of the firm, an issue which has been largely neglected in the literature on investment expenditure.

7.4 Inflation Uncertainty and Economic Activity

Empirical studies by Levi and Makin (1979, 1980) and by Mullineaux (1980) have found that inflation uncertainty measured by a high variance of inflationary expectations across Livingston survey responders is both positively correlated with inflation "surprises" and has a significant negative impact on real variables. These results are tied to earlier works by the findings of Cuckierman and Wachtel (1979), employing Livingston data, that large variance in inflation is associated with large variance of inflationary expectations across survey responders. Taken together, this body of literature suggests that a measure of inflation uncertainty ought to be included in tests of the Rational expectations hypothesis and further, that in view of the positive correlation between inflation uncertainty and monetary surprises (see Levi and Makin (1980)) omission of inflation uncertainty from tests of the rational expectations hypothesis could introduce bias implicit in an omitted variable problem.

The specific effect of inflation uncertainty hypothesized here is a negative impact on the rate of change of output. Allowing for an effect of uncertainty about inflation on output means modifying our Lucas-Sargent representation of the natural rate hypothesis and writing.

$$Q_t = a + Q_{t-1} + \gamma(P_t - P_t^*) + \lambda V_t + e_t \qquad (7.3)$$

where Q_t = the rate of change in output

Q_{t-1} = the state of change in output at t-1

P_t = is the actual inflation rate in period t

P_t^* = is the expected inflation rate for period t

V_t = is a measure of uncertainty concerning future inflation during forecast period t

If the V_t terms are excluded one obtains a version of the natural-rate hypothesis tested by Sargent (1973, 1976).

The term $(P_t - P_t^*)$ represents the unexpected part of the current inflation rate, which as we have seen according to Friedman - Phelps theory should have a positive influence on output.

The aim of deriving equation (7.3) however was not only to see whether unexpected inflation and inflation uncertainty affects output, but as we mentioned at the beginning of this chapter to find a link between inflation uncertainty, output and investment. If as predicted by the theory inflation uncertainty affects output a proxy for economic activity and as output is a determinant on the neoclassical investment model, then an indirect link may be found between inflation uncertainty and Investment.

The estimation equation derived from the standard Neoclassical Investment model was given by equation (6.7) in the previous chapter, and by excluding the inflation uncertainty term may be written as:

$$I_t = a^{\sigma} \sum_{j=1}^{N} \omega_j [(P/c)_t^{\sigma} Q_t - (P/c)_{t-1}^{\sigma} Q_{t-1}] + dk_{t-1} + e_t \quad (7.4)$$

By partially differentiating (7.4) with respect to output we obtain:

$$\frac{dI}{dQ_t} = a^{\sigma} \Sigma \omega_j (P/c)_t^{\sigma} \tag{7.5}$$

Now differentiating equation (7.3) with respect to unexpected part of inflation $(P_t - P_t^*)$ we obtain:

$$\frac{dQ}{d(P_t - P_t^*)} = \gamma \tag{7.6}$$

but $$\frac{dI}{d(P_t - P_t^*)} = \frac{dI}{dQ_t} \cdot \frac{dQ}{d(P_t - P_t^*)} \tag{7.7}$$

substituting (7.6) and (7.5) into equation (7.7) we obtain the effect of unexpected inflation on investment:

$$\frac{dI}{d(P_t - P_t^*)} = \gamma \; a^{\sigma} \Sigma \omega_j (P/c)_t^{\sigma} \tag{7.8}$$

Similarly by differentiating equation (7.3) with respect to inflation uncertainty term (V_t) we obtain:

$$\frac{dQ}{dV_t} = \lambda \tag{7.9}$$

but $$\frac{dI}{dV_t} = \frac{dI}{dQ_t} \cdot \frac{dQ_t}{dV_t} \tag{7.10}$$

Substituting (7.5) and (7.9) into equation (7.10) we obtain the effect of inflation uncertainty on investment:

$$\frac{dI}{dV_t} = \lambda\ a^{\sigma}\ \Sigma\ \omega_j (P/c)_t^{\sigma} \tag{7.11}$$

The overall effect on Investment therefore would be seen by taking the difference between equation (7.8), the unexpected part of inflation, and equation (7.11) the inflation uncertainty term, which according to theory should be negative, and is given by equation (7.12)

$$\lambda\ a^{\sigma}\ \Sigma\ \omega_j (P/c)_t^{\sigma} - \gamma\ a^{\sigma}\ \Sigma\ \omega_j (P/c)_t^{\sigma} < 0 \tag{7.12}$$

In estimating equation (7.3) once again as with the investment equation we employ two different estimates for expected inflation and inflation uncertainty series, in order to see whether the results are affected by different forecasts. Firstly expectations are approximated by a distributed lag on actual consumer price index and secondly an expected series is achieved through an ARIMA model. For the inflation uncertainty variable uncertainty was measured with the standard deviation of expected inflation forecasts for a two year horizon. Data for the rate of change in output when taken from Economic trends published by

CSO. Equation (7.3) was estimated by the use of regression analysis and their results are presented in the next chapter. The period of estimation was identical to that used for estimating the investment equation.

CHAPTER VIII

EMPIRICAL RESULTS

The purpose of this chapter is to provide an empirical analysis of the effects of inflation and inflation uncertainty on manufacturing investment. This analysis is designed to answer four basic questions: (1) Does the interaction of inflation and historic cost depreciation rules lead to a decline in manufacturing investment? (2) Does inflation reduce equipment investment more than structures investment?, (3) Do the effects of inflation on investment vary over different sets of economic assumptions?, and (4) Do increases in inflation uncertainty reduce manufacturing investment?

The results presented in this chapter are based chiefly on the estimated coefficients from two investment equations. These equations are estimated utilizing the ordinary least square (OLS) method, applied on a time series data of the U.K. manufacturing sector. The estimated coefficients serve as a direct input to a simulation procedure designed to measure the effects of inflation and inflation uncertainty on manufacturing investment. The results of this study represent the only evidence available to answer the above questions. The first part of this chapter reviews the equation estimates, the second part describes the simulation procedure, and presents the measured effects of inflation on manufacturing investment, and part three deals with the measured effects of inflation uncertainty on investment.

8.1 <u>The Estimation of the Neoclassical Investment Model for the U.K. Manufacturing Sector</u>

The neoclassical investment model was estimated separately for equipment and structures. Recall from chapter VI that the general functional specification is described by:

$$I_t=a_0+a^{\sigma}\sum_{j=1}^{n}\omega_j[(P/c)_t^{\sigma}Q_t-(P/c)_{t-1}^{\sigma}Q_{t-1}] + dK_{t-1}+et \quad (8.1)$$

where I_t = gross investment, equipment or structures

a^{σ} = the elasticity of capital with respect to output, equipment or structures.

ω_j = lag distribution or changes on the optimal capital stock, equipment or structures.

P = the price of output

c = the user cost of capital, equipment or structures.

Q_t = is the output

σ = the elasticity of substitution, equipment or structures.

K_{t-1} = actual capital stock at (t-1), equipment or structures.

Following from our methodology preliminary experimentations were conducted in order to estimate or determine certain characteristics of each model. Firstly each investment model was adjusted for inflation, through the user cost of capital concept (see chapter VI). Secondly the assumption of Cobb - Douglas production function (i.e. unitary elasticity of the desired capital stock with respect to relative prices) was relaxed, and for estimation purposes a range of values in the interval [0,1] were used, and thirdly the most appropriate lag pattern of investment and optimal capital stock were selected for each investment equation.

A considerable amount of computer time was used to estimate the appropriate combination of elasticity and number of lags. Using the correlation coefficient as a criterion (i.e. the highest R^2 adjusted for degrees of freedom, and corrected for autocorrelation) the following values were selected. For both specifications, the distributed lag weights were constrained to fit a third degree polynomial (with 16 quarters of lags, all positive and the peak occurring at 9 or 10) giving a preferred value of elasticity of substitution of 0.25. These results are in line with the studies of Boatwright and Eaton (1972), Savage

(1977), Jenkinson (1981), Bean (1981), and Bosworth (1984).

However the estimated elasticity of o.25 contradicts Jorgenson's assumption of a Cobb - Douglas production function and is consistent with the properties of CES production function with elasticities of substitution closer to zero than unity. Nevertheless despite the low value of the elasticity the role of relative prices, the critical element in the Neoclassical approach is confirmed.

For each investment model the total sample period (1967:2 - 86:4) was employed and the results are presented in Tables 1 and 2 respectively. Each table shows different measures of the nominal discount rate that is used to estimate the present value of the future stream of allowances. As it was discussed in chapter VI this discount rate could be estimated by adding the rate of inflation to the estimated real discount rate, following the Fisher hypothesis which states, that nominal interest rates adjust fully to expected inflation. However there is a great divergence of opinion about the theoritical and empirical implications of the Fisher postulate for real world behaviour. As a result of that Nickell (1978) suggests that inflationary expectations term may have a lower weight in the real cost of capital, than implied by the theoretical formulae, due to recent evidence on the Fisher hypothesis, and following his argument alternative equations have been estimated with the weight of the inflationary expectations term varying from 0.3 to 1.0. Furthermore the equations were estimated by using a discount rate equal to the rate of five year British Government stock. The reason for the latter is for comparison purposes.

From Table 1 it can be seen that in each case for 95% level of significance the constant is not significantly different than zero, where as the remaining regression coefficients are significantly different than zero. It is also apparent that the F - statistic in each case is greater than the critical F - value of 2.45 (5.73 degrees of freedom, level of significance 95%) a result indicating the significance of each linear relationship as a whole. The F - test can also be thought of as a test for significance of the correlation coefficient R^2. The values of R^2 are ranging between 38.6% (when the rate on five - year British Government stock is used as a distant rate) to 44.6% (when a weight of 0.4 for inflation is used). From this result it can be calculated that in the case of equipment and for the total sample period that the best explanatory power of the model is obtained when a weight of 0.4 inflation is utilized.

TABLE 1

The estimation of the Neoclassical Model for the U.K. Manufacturing Sector (Equipment, Period 1967:2-86:4)[1]

Different measures of the discount rate that is used to estimate the the Present value of the future stream of Allowances	Constant	$a^{\sigma}\sum_{j=1}^{16}\omega_j$	d	F-Statistic[2]	Durbin-Watson[3] (DW)	R^2 Corrected for autocorrelation[4]
Nominal = Real + 0.3 Inflation	1.073 (1.53)[5]	53.2 (2.48)	0.06 (2.10)	7.1	2.0	41.1%
Nominal = Real + 0.4 Inflation	1.092 (1.72)	66.2 (2.67)	0.09 (2.31)	8.1	2.1	44.6%
Nominal = Real + 0.6 Inflation	1.063 (1.67)	63.3 (2.54)	0.004 (2.29)	7.9	2.1	42.3%
Nominal = Real + 0.7 Inflation	1.035 (1.48)	55.3 (2.41)	0.004 (2.19)	7.4	2.2	41.6%
Nominal = Real + Full Inflation	1.024 (1.41)	50.2 (2.41)	0.003 (2.18)	7.1	2.0	41.2%
Nominal = [Rate on five-year British government stock	873.5 (1.81)	33.4 (2.39)	0.008 (2.09)	6.9	2.3	38.6%

1. Estimated equation: $I_t = a_0 + a^{\sigma}\sum_{j=1}^{16}\omega_j [(P/C)_t^{\sigma}Q_t - (P/C)_{t-1}^{\sigma}Q_{t-1}] + dK_{t-1} + et$
2. The critical value for the F-Statistic is approximately 2.45 (5,73 degrees of Freedom, level of significance 95%)
3. No autocorrelation Dw=2, positive autocorrelation Dw<2, and negative autocorrelation Dw>2.
4. The correlation coefficient is adjusted for degrees of Freedom
5. T-Statistic are shown in Parenthesis. Critical value is aproximately 2.00 (73 degrees of Freedom, two tailed test, level of significance 95%)

TABLE 2

The estimation of the Neoclassical Model for the U.K. Manufacturing Sector (Structures, Period 1967:2-86:4)[1]

Different measures of the discount rate that is used to estimate the the Present value of the future stream of Allowances	Constant	$a^{\sigma}\sum_{j=1}^{16}\omega_j$	d	F-Statistic[2]	Durbin-Watson[3] (DW)	R^2 Corrected for autocorrelation[4]
Nominal = Real + 0.3 Inflation	563.6 (1.21)[5]	49.6 (3.15)	0.008 (2.13)	4.8	2.0	47.6%
Nominal = Real + 0.4 Inflation	498.2 (1.15)	35.3 (2.94)	0.007 (2.74)	4.3	2.0	43.2%
Nominal = Real + 0.6 Inflation	203.7 (0.267)	38.2 (2.84)	0.007 (2.11)	4.4	2.0	44.1%
Nominal = Real + 0.7 Inflation	365.6 (0.489)	36.8 (2.41)	0.009 (2.91)	4.4	2.1	43.4%
Nominal = Real + Full Inflation	162.13 (0.20)	30.6 (2.39)	0.004 (2.15)	4.1	1.98	42.6%
Nominal = [Rate on five-year British government stock	521.2 (0.69)	19.2 (2.59)	0.007 (2.29)	4.0	2.0	41.3%

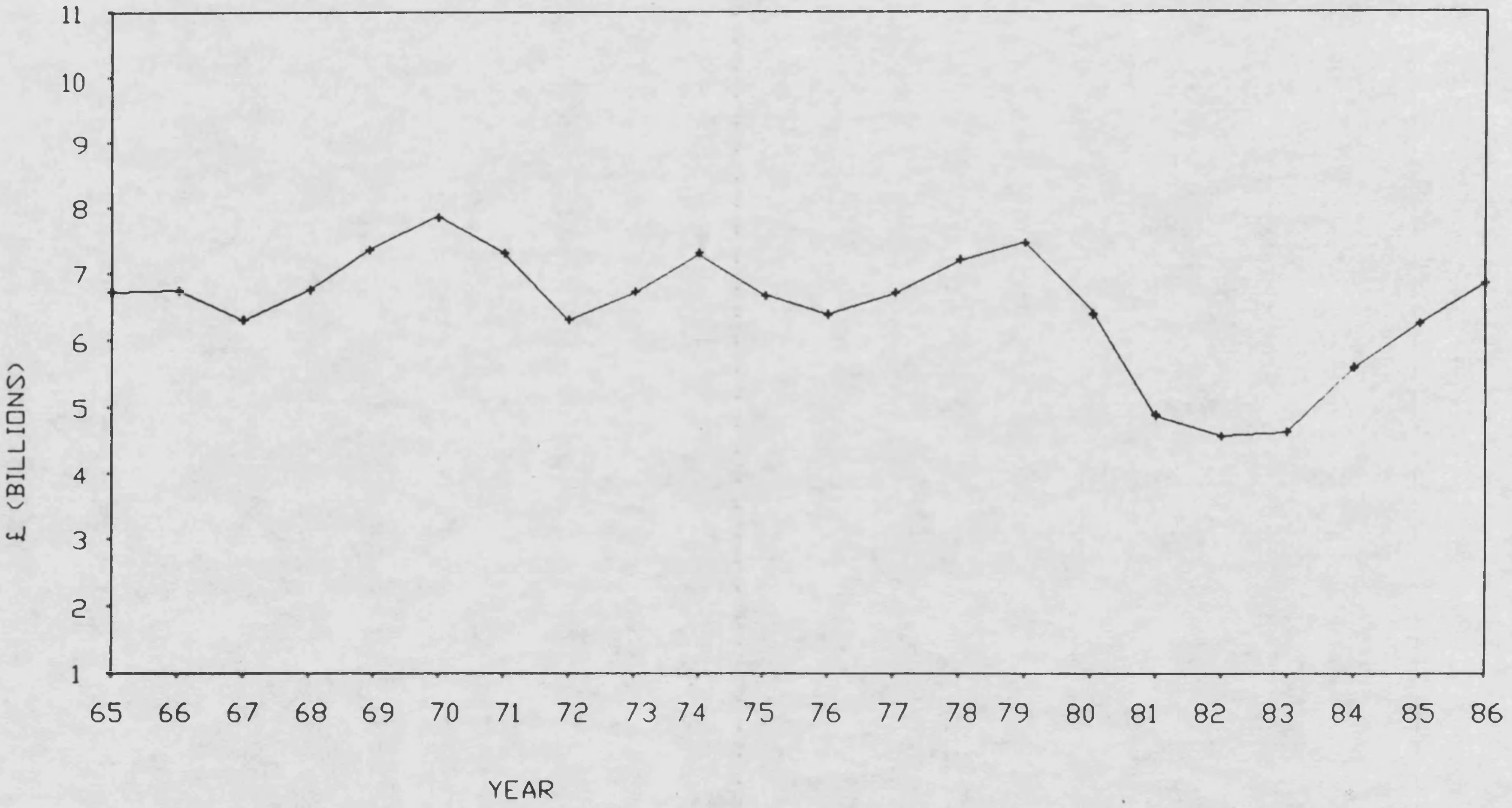
1. Estimated equation: $I_t = a_0 + a^{\sigma}\sum_{j=1}^{16}\omega_j \, [(P/C)_t^{\sigma}Q_t - (P/C)_{t-1}^{\sigma}Q_{t-1}] + dK_{t-1} + et$
2. The critical value for the F-Statistic is approximately 2.45 (5,73 degrees of Freedom, level of significance 95%)
3. No autocorrelation Dw=2, positive autocorrelation Dw<2, and negative autocorrelation Dw>2.
4. The correlation coefficient is adjusted for degrees of Freedom
5. T-Statistic are shown in Parenthesis. Critical value is aproximately 2.00 (73 degrees of Freedom, two tailed test, level of significance 95%).

Although the weight of 0.4 of inflation gives the highest R^2 the magnitude of this coefficient is only 44.6% (i.e. 44.6 % of the variability of investment in equipment is explained by the variability of the optimal capital stock and actual capital stock. Similar results are obtained for structures, (Table 2), with the only difference being that the inflation weight of 0.3 gives the highest explanatory power (i.e. correlation coefficient of 47.6%).

A possible explanation for the low values of the correlation coefficient is the large number of outliers (actual investment values minus estimated investment values) present in both equations, equipment and structures after the second quarter of 1980. A plot of fixed capital expenditure figure 8.1 by the manufacturing sector reveals a sharp decline in the manufacturing investment after 1980 before stabilizing in 1982 and 1983. In spite of this recovery of investment, the volume of capital expenditure by manufacturing industry were still low compared to its 1979-80 level. Therefore changes in the desired capital stock were not sufficient to explain the magnitude of this decline. Levis and Morgan (1985) suggest that liquidity considerations have exerted a stronger and more direct influence on fixed investment decisions since 1980 than ever before, and by including a measure

Figure 8.1

FIGURE 1 GROSS FIXED INVESTMENT IN MANUFACTURING INDUSTRY
SEASONALLY ADJUSTED AND AT 1980 PRICES



for liquidity in their modified Neoclassical model the fit of the model improved marketably.

To investigate whether the outliers present in both equipment and structures determine the explanatory power of the model it was decided to exclude the period after the second quarter of 1980. Considering only 53 quarterly observations (i.e. 1967:2 - 80:2) both investment equations were estimated and their results are presented in Tables 3 and 4 respectively.

Looking at Table 3 we observe that the regression coefficients are significantly different than zero at a 95% level of significance, and each relationship as a whole is significant at the same level (as shown from the estimated F-statistics). The correlation coefficient is substantially improved for each different nominal measure of the discount rate. These results also reaffirm that the highest explanation power is occurred when the inflation weight is 0.4, and also indicate the problem of the outliers existing during the total sample period. Similar results are also obtained for structures using the sample period (1967:2 - 1980:2), and the highest explanatory power is observed again when the inflation weight of 0.4 is added to the real cost of capital. Furthermore in theory, the estimated coefficients d on the replacement

TABLE 3

The estimation of the Neoclassical Model for the U.K. Manufacturing Sector (Equipment, Period 1967:2-80:2)[1]

Different measures of the discount rate that is used to estimate the the Present value of the future stream of Allowances	Constant	$a^{\sigma}\sum_{j=1}^{16}\omega_j$	d	F-Statistic[2]	Durbin-Watson[3] (DW)	R^2 Corrected for autocorrelation[4]
Nominal = Real + 0.3 Inflation	796.7 (2.8)[5]	68.3 (2.53)	0.012 (3.36)	11.9	2.0	57.3%
Nominal = Real + 0.4 Inflation	777.6 (2.22)	70.2 (2.43)	0.012 (3.38)	12.0	2.1	58.2%
Nominal = Real + 0.6 Inflation	669.1 (2.2)	70.0 (2.45)	0.012 (3.39)	11.7	2.1	56.9%
Nominal = Real + 0.7 Inflation	687.1 (2.8)	63.2 (2.1)	0.011 (3.27)	11.4	2.1	56.7%
Nominal = Real + Full Inflation	672.2 (2.2)	67.1 (2.4)	0.09 (3.36)	11.0	2.1	53.8%
Nominal = [Rate on five-year British government stock	187.4 (1.6)	53.1 (2.06)	0.010 (2.48)	10.4	2.1	52.1%

1. Estimated equation: $I_t = a_0 + a^{\sigma}\sum_{j=1}^{16}\omega_j\,[(P/C)_t^{\sigma}Q_t - (P/C)_{t-1}^{\sigma}Q_{t-1}] + dK_{t-1} + et$
2. The critical value for the F-Statistic is approximately 2.45 (5,47 degrees of Freedom, level of significance 95%)
3. No autocorrelation Dw=2, positive autocorrelation Dw<2, and negative autocorrelation Dw>2.
4. The correlation coefficient is adjusted for degrees of Freedom
5. T-Statistic are shown in Parenthesis. Critical value is aproximately 2.021 (47 degrees of Freedom, two tailed test, level of significance 95%).

TABLE 4

The estimation of the Neoclassical Model for the U.K. Manufacturing Sector (Structures, Period 1967:2-80:2)[1]

Different measures of the discount rate that is used to estimate the the Present value of the future stream of Allowances	Constant	$a^{\sigma}\sum_{j=1}^{16}\omega_j$	d	F-Statistic[2]	Durbin-Watson[3] (DW)	R^2 Corrected for autocorrelation[4]
Nominal = Real + 0.3 Inflation	413.2 (2.47)[5]	52.4 (5.64)	0.008 (2.10)	5.9	2.1	71.3%
Nominal = Real + 0.4 Inflation	495.5 (1.15)	66.9 (5.32)	0.013 (2.25)	7.0	1.9	82.6%
Nominal = Real + 0.6 Inflation	472.4 (2.26)	62.3 (5.12)	0.013 (2.29)	6.6	2.0	77.1%
Nominal = Real + 0.7 Inflation	493.5 (2.31)	60.9 (5.42)	0.009 (2.16)	6.2	2.0	75.1%
Nominal = Real + Full Inflation	488.1 (2.25)	59.9 (5.99)	0.004 (2.08)	6.0	2.0	74.4%
Nominal = [Rate on five-year British government stock]	153.2 (2.61)	34.8 (3.07)	0.009 (2.21)	5.2	2.0	63.8%

1. Estimated equation: $I_t = a_0 + a^{\sigma}\sum_{j=1}^{16}\omega_j \left[(P/C)^{\sigma}_t Q_t - (P/C)^{\sigma}_{t-1} Q_{t-1}\right] + dK_{t-1} + et$
2. The critical value for the F-Statistic is approximately 2.45 (5,47 degrees of Freedom, level of significance 95%)
3. No autocorrelation Dw=2, positive autocorrelation Dw<2, and negative autocorrelation Dw>2.
4. The correlation coefficient is adjusted for degrees of Freedom
5. T-Statistic are shown in Parenthesis. Critical value is aproximately 2.021 (47 degrees of Freedom, two tailed test, level of significance 95%).

investment variable K should approximate the assumed values of economic depreciation for equipment and structures capital (i.e. d_E=0.06 and d_S=0.04). The estimates of these parameters shown in Tables 3 and 4 are a little low relative to the assumed values, but the difference is not large though to indicate an estimated problem.

In order to exclude the possibility of multicollinearity regressions were run between the explanatory variables. the results (not presented here) indicate a relatively low correlation coefficient and thus excluding the possibility of multicollinearity between the explanatory variables.

The results presented in Tables 1 to 4 indicate that the inflation adjustments proposed by this study improve the explanatory power of the investment model for both equipment and structures. For example from Table 3 it can be seen that the inflation adjustment produces an R^2 coefficient ranging from 53.8% to 58.2% as compared with that of 52.1% when inflation is not considered. Similarly from Table 4 the inflation adjustment produces an R^2 ranging between 71.3% to 82.6% as compared with only 63.8% when inflation is not used. Clearly these results are in line with the theoretical conclusions presented in chapter IV and highlight the superiority of the inflation adjustment for both models.

In estimating equation (8.1) we employed two different estimates for expected inflation series in order to see whether the results were affected by different forecasts. As mentioned in the methodology chapter expectations were approximated using firstly a distributed lag on actual consumer price index and secondly an expected series was achieved through an ARIMA model. The outcome of this experimentation indicated that the investment equations were not sensitive to different forecasts of inflation.

The results presented in this section are in line with those of Felstein (1982) using U.S.A. data. The only difference is that his empirical results show a Cobb - Douglas production function taking value approximately equal to one, as the initial study of Jorgenson (1963). On the other hand, the evidence provided by Feldstein (1982), shows that a correct accounting of the impact of inflation improves the ability of the analysis to explain the variation in investment over the past 25 years.

Finally to evaluate the potential impact of tax exhaustion on investment behaviour, the neoclassical investment model was run again using an average effective corporation tax rate. These latter results however were rather disappointing. The fit of the equations worsened for the total sample period as well as for earlier subperiods. A possible explanation is provided by Levis and Morgan (1985) who suggest that a full evaluation of this issue would require the application of a disaggregated model of corporate investment behaviour.

8.2 Measured Effects of Inflation on Manufacturing Investment

Measurement of the effects of inflation and historic cost depreciation on investment requires estimates of the parameter $\hat{a}^{\sigma}$ the elasticity of output with respect to capital input for both equipment and structures. Since however the post 1980 model is heavily influenced by the unusual circumstances of the 1979 - 80 recession, and might not be representative of long-term corporate investment behaviour, these parameters were calculated using the estimated coefficients of $a^{\sigma} \sum_{j=1}^{16} \omega_j$ shown in Tables 3 and 4, for the subperiod 1967:2 - 1980:2. The actual coefficients of $a^{\sigma} \sum_{j=1}^{16} \omega_j$ were 70.2 and 66.9 for both equipment and structures respectively.

The procedure for calculating $\hat{a}^{\sigma}$ from the sequence of lag coefficients was discussed in the chapter of methodology. The resulting estimates of $\hat{a}^{\sigma}$ are shown in Table 5.

TABLE 5

Estimated Elasticities of Output

Equation	$\hat{a}^{\sigma}$
Equipment ($\hat{a}^{\sigma}_{E}$)	0.035
Structures($\hat{a}^{\sigma}_{S}$)	0.018

Using annual data for manufacturing investment, Hall and Jorgenson estimate $\hat{a}_E = 0.07$ and $\hat{a}_S = 0,03$. Jorgenson and Stephenson report values of $\hat{a}$ for total investment for each industry (sum of equipment and structures) which range from 0.01 for Foods and Beverages to 0.08 for Motor Vehicles and Equipment. Aggregating the same data set, Jorgenson and Stephenson compute a total manufacturing investment elasticity of 0.06. The estimated elasticities in this study differ from those reported by Hall and Jorgenson for two reasons.

First, is the obvious reason, of examining two different countries, and therefore facing different data sets. However in addition to that the estimates of $\hat{a}$ will differ from those obtained by Hall and Jorgenson due to differences in the measurement of the user cost of capital variables. The discussion in chapter IV demonstrates that when tax depreciation deductions are based on historic asset purchase prices, inflation increases the value of the user cost of capital relative to that calculated for zero inflation of replacement cost depreciation. Theory suggests that changes in the user cost can be significant with positive inflation rates, and that serious measurement errors can occur of such effects are ignored.

Analysis of the procedure used by Hall and Jorgenson to construct estimates of user cost of capital for equipment and structures shows that no adjustment was made in the calculations to account for the interaction of inflation and historic cost depreciation. In fact, these authors: (1) assumed that the real and nominal after - tax costs of finance to the firm are always equal, and (2) set the before - tax cost of finance equal to a constant twenty - percent. Under these conditions, changes in the value of depreciation result only from tax policy changes. Significantly, inflation rates were not very high over this period, but as the results later in this section demonstrate, even low values of inflation will significantly affect the user cost of capital and investment demand. For these reasons, the estimated values of $\hat{a}$ obtained by Hall and Jorgenson are more likely to suffer from the problem of errors in variables than are those used in this study.

With the estimates of $\hat{a}^{\sigma}$ shown in Table 5, we can pursue measurement of the effects of inflation on manufacturing investment. Recall from chapter VI that measurement of such effects may be accomplished by evaluating the following derivative for both equipment and structures:

$$\frac{dI}{dP^*} = d.\frac{dK^*}{dP^*} = \frac{-d(\hat{a}^{\sigma}P^{\sigma}\sigma c^{\sigma})Q}{c_0^{*3}}.\frac{dc^*}{dP^*} \qquad (8.2)$$

where d = economic depreciation rate, equipment or structures

P = price of output

Q_t = is the output

σ = the elasticity of substitution, equipment or structures

c_0^* = value of the user cost of capital prior to the change in inflation, equipment or structures

$\hat{a}^{\sigma}$ = elasticity of output with respect to capital input, equipment or structures

Equation (8.2) provides a partial equilibrium estimate of the effect of inflation on equipment and structures investment. The long - term effect of inflation on gross investment is approximated by the calculated change in the optimal capital stock multiplied by the economic depreciation rate.

In equilibrium, gross investment equals the replacement investment necessary to maintain a constant optimal stock of capital. Given an increase in inflation, the optimal stock of capital declines, leading to a decline in gross investment consistent with the maintenance of a smaller capital stock. The estimated change in the levels of equilibrium gross investment provides a measure of the long - term effect of a change in inflation.

This estimate is partial equilibrium in the sense that all other elements of the optimal capital stock variables are assumed to remain constant, regardless of the change in investment. Such an assumption may seem unreasonable at first, but it provides the only consistent way to measure the effects of inflation on gross investment.

Therefore assuming initial values for c_0^*, P, Q, $\hat{a}^\sigma$, and d, we can evaluate the effect of inflation on investment by computing the effect of inflation on the user cost of capital changes in the user cost of capital are computed by resolving the depreciation formulas of chapter VI using the nominal finance rate which corresponds to the assumed level of inflation. Separate calculations performed for both equipment and structures investment provide a basis for measuring the extent to which inflation affects the level and composition of real business investment.

As the analysis in chapter IV demonstrates, the effects of a change in inflation on investment are also critically dependent on the assumed values of real asset purchase prices and real finance rates. The effects of inflation on the user cost of capital are found to vary under different assumptions of these parameters, indicating that the sensitivity of investment to changes in inflation will not be constant. To evaluate the importance of these parameters in measuring the effects of inflation on investment, I simulate equation (8.2) over a wide range of real after - tax finance rates and asset purchase prices, at the last quarter of the sample period.

The steps involved in this process are as follows: I first select values of equipment and structures real asset purchase prices. These different cases are examined. For case 1, I use the actual 1980 value of the Price deflator for Gross Domestic Product as reported in Economic Trends by the C.S.O. The deflator for each investment good is divided by the deflator for Gross Domestic product to obtain estimates of real asset purchase prices for equipment and structures. In case 2, I arbitrarily set the real asset prices equal to unity, and in case 3, I use the inverse of the asset price used in case 1. Each case, therefore, employs a different base assumption on asset purchase prices for use in the simulations.

For each case, I then select value for the real after-tax finance rate $\tilde{r}$ discussed in chapter VI and compute the corresponding value of c_0^*, assuming a zero inflation rate. Holding the real after - tax finance rate constant, the inflation rate is increased from zero to a new level, which is assumed to increase the nominal finance rate by the full amount of the change in inflation. Under the assumption of historic cost depreciation rules, the increase in the nominal finance rate leads to a decline in the real value of depreciation deductions and an increase in the user cost of capital. Using equation (8.2), the change in investment from the exogenous change in inflation can then be estimated. The effects of inflation on investment under alternative initial finance rates is calculated by reinitializing c_0^* based on new values of $\bar{r}$. This procedure is repeated for each of the three scenarios for real asset prices discussed above. In this manner, I emphasize the significance of varying initial assumptions on asset purchase prices and real finance rate to measurement of the effects of inflation on investment.

Tables 6 - 8 show the simulated effects of inflation on investment which result from the steps described above. The entries on each of these tables represent the estimated long - run change in manufacturing equipment and structures investment brought about by an increase in inflation. The inflation rate is assumed to increase from zero to the selected levels of P^*, leading to the measured change in investment for both asset types. Each experiment is repeated for different assumptions on the real finance rate identified in the first column of each Table. Finally, Tables 6 - 8 correspond to each of the three assumed values of the asset purchase prices discussed as case 1, case 2, and case 3 above.
The data provided in these Tables substantiates the theoretical prediction that inflation significantly reduces investment, and that such effects are present even at low rates of inflation. By reducing the present value of depreciation deductions based on historic cost tax rules, inflation reduces investment relative to

TABLE 6

Estimated Impact on Manufacturing Investment of %
a change in the Inflation Rate from zero to P^*

Real Finance Rates	Asset Type	Expected Inflation Rate 2%	4%	6%	8%	10%	12%
2%	ΔIE	-2.21	-5.00	-6.6	-8.3	-9.8	-11.2
	ΔIS	-0.73	-1.56	-2.18	-2.41	-2.47	-2.52
4%	ΔIE	-0.91	-1.51	-2.28	-2.73	-3.19	-3.82
	ΔIS	-0.49	-0.75	-1.26	-1.52	-1.90	-2.41
6%	ΔIE	-0.26	-0.56	-0.89	-0.98	-1.30	-1.45
	ΔIS	-0.13	-0.42	-0.71	-0.76	-1.00	-1.11
8%	ΔIE	-0.16	-0.29	-0.43	-0.59	-0.66	-1.12
	ΔIS	-0.11	-0.22	-0.33	-0.42	-0.48	-0.79
10%	ΔIE	-0.012	-0.19	-0.31	-0.39	-0.53	-0.62
	ΔIS	-0.078	-0.13	-0.21	-0.26	-0.30	-0.37
12%	ΔIE	-0.11	-0.15	-0.22	-0.29	-0.37	-0.49
	ΔIS	-0.056	-0.09	-0.12	-0.16	-0.20	-0.24

Indices for real asset purchase prices for case 1: $P_E = 0.95$, $P_S = 0.90$

TABLE 7
Estimated Impact on Manufacturing Investment of %
a change in the Inflation Rate from zero to P^*

Real Finance Rates	Asset Type	Expected Inflation Rate 2%	4%	6%	8%	10%	12%
2%	ΔIE	-1.62	-3.71	-5.17	-6.23	-7.34	-8.38
	ΔIS	-0.64	-1.36	-1.91	-2.11	-2.16	-2.21
4%	ΔIE	-0.75	-1.21	-1.93	-2.64	-2.75	-3.23
	ΔIS	-0.42	-0.64	-1.08	-1.3	-1.62	-2.06
6%	ΔIE	-0.19	-0.41	-0.59	-0.73	-0.89	-1.00
	ΔIS	-0.11	-0.35	-0.58	-0.63	-0.82	-0.92
8%	ΔIE	-0.12	-0.20	-0.29	-0.41	-0.47	-0.79
	ΔIS	-0.09	-0.19	-0.28	-0.37	-0.44	-0.68
10%	ΔIE	-0.08	-0.13	-0.23	-0.31	-0.35	-0.42
	ΔIS	-0.06	-0.115	-0.18	-0.22	-0.26	-0.32
12%	ΔIE	-0.06	-0.09	-0.13	-0.17	-0.21	-0.26
	ΔIS	-0.04	-0.07	-0.09	-0.13	-0.16	-0.19

Indices for real asset purchase prices for case 2: $P_E = P_S = 1.0$

TABLE 8

Estimated Impact on Manufacturing Investment of % a change in the Inflation Rate from zero to P^*

Real Finance Rates	Asset Type	Expected Inflation Rate 2%	4%	6%	8%	10%	12%
2%	ΔIE	-1.95	-4.41	-5.88	-7.36	-8.64	-9.8
	ΔIS	-0.86	-1.86	-2.60	-2.88	-2.94	-3.0
4%	ΔIE	-0.78	-1.29	-1.95	-2.69	-2.86	-3.42
	ΔIS	-0.57	-0.86	-1.45	-1.75	-2.18	-2.71
6%	ΔIE	-0.22	-0.51	-0.84	-0.94	-1.26	-1.40
	ΔIS	-0.15	-0.49	-0.82	-0.88	-1.16	-1.29
8%	ΔIE	-0.14	-0.26	-0.39	-0.51	-0.61	-0.96
	ΔIS	-0.12	-0.25	-0.37	-0.48	-0.55	-0.91
10%	ΔIE	-0.11	-0.18	-0.28	-0.36	-0.45	-0.51
	ΔIS	-0.09	-0.16	-0.26	-0.32	-0.39	-0.41
12%	ΔIE	-0.10	-0.13	-0.18	-0.23	-0.28	-0.36
	ΔIS	-0.07	-0.11	-0.15	-0.20	-0.25	-0.30

Indices for real asset purchase prices for case 3: $P_E = 0.9$, $P_S = 0.95$, i.e inverse of case 1.

that which would occur under zero inflation (or, alternatively, under perfectly indexed depreciation deductions). Theoretical predictions developed by Hendershott and Hu (1981), Feldstein (1981), Kopke (1981), and Auerbach (1979) are thus born out by these empirical results. This result is invariant with respect to different initial assumptions on real finance rates and real asset purchase prices.

These Tables also substantiate the predictions of chapter IV that inflation has a greater negative impact on equipment investment than structures investment. By comparing the ΔIE and ΔIS values in Tables 6 - 8, we can see that $\Delta IE > \Delta IS$ under all possible initial assumptions on real finance rates and asset purchase prices. This finding is consistent with the results of Hendershott and Hu (1981c), and the discussion presented in chapter IV. Because inflation reduces investment in equipment more than structures, the composition of investment will be biased toward structures purchases in the aggregate.

Of equal importance is the finding that inflation will affect investment differently under various economic conditions. As the data in Tables 6 - 8 indicate, different assumed values of real asset purchase prices and real finance rates lead to greatly different estimates of the change in investment. For example, an increase in the inflation rate from zero to four percent on Table 7 leads to a decline in equipment investment of 1.21 percent when the real interest rate rises to six percent, however, the expected change in equipment investment is only 0.41 percent. Similarly, differences in real asset prices are found to significantly alter the predicted effect of inflation on investment given an exogenous change in inflation. These findings reinforce the idea that the relation between inflation, historic cost depreciation and investment is likely to change over time.

8.3 Measured effects of inflation uncertainty on Manufacturing Investment

As it has been discussed in chapter V theory suggests that inflation uncertainty should influence aggregate Investment. To investigate the validity of this hypothesis it was decided to include an additional explanatory variable in each investment equation. This variable measures the inflation uncertainty and it can be calculated by using the standard deviation of the forecasted expected inflation series.

For similar reasons explained in Section 7.1 the two investment equations were estimated using the total sample period 1967:2-1986:4 as well as the subperiod

1967:2-1980:2. These results are presented in Tables 9 to 12. From Table 9 it can be seen that the coefficient of inflation uncertainty has the correct sign (negative), but it is not significantly different than zero, at the 95% level of significance. These results clearly indicate that the inflation uncertainty is not a factor influencing the aggregate investment in equipment. The remaining explanatory variables have coefficients which are significantly different than zero and the explanatory power of the model (as measured by R^2) remains unaffected.

To exclude the possibility that these results are due to the unusual circumstances of the 1979-80 recession, the equation was estimated again, as shown in Table II, using the subperiod 1967:2-1980:2. Unfortunately as the results indicate no improvement was achieved. Taken together the results of Tables 9 and II, it can be deduced that inflation uncertainty does not directly affect aggregate investment in equipment.

Similar experiments (see Tables 10, 12) were performed for the case of structures and again the results indicate that inflation uncertainty does not directly influence aggregate investment in structures.

TABLE 9

The estimation of the Neoclassical Model for the U.K. Manufacturing Sector (Equipment, Period 1967:2-86:4)[1]

Different measures of the discount rate that is used to estimate the the Present value of the future stream of Allowances	Constant	$a^{\sigma}\sum_{j=1}^{16}\omega_j$	d	λ	F-Statistic[2]	Durbin-Watson[3] (DW)	R^2 Corrected for autocorrelation[4]
Nominal = Real + 0.3 Inflation	794.5 (1.72)[5]	52.8 (2.40)	0.006 (2.03)	-7.6 (-0.44)	7.0	2.0	41.1%
Nominal = Real + 0.4 Inflation	781.2 (1.34)	65.7 (2.87)	0.005 (2.12)	-7.8 (-0.45)	8.1	2.1	44.6%
Nominal = Real + 0.6 Inflation	759.3 (1.13)	62.9 (2.96)	0.007 (1.98)	-14.8 (-0.83)	7.8	2.1	42.2%
Nominal = Real + 0.7 Inflation	756.9 (0.97)	55.0 (3.12)	0.009 (2.01)	-8.1 (-1.25)	7.4	2.2	41.6%
Nominal = Real + Full Inflation	747.03 (0.97)	50.1 (3.22)	0.006 (1.92)	-8.4 (-0.5)	7.0	2.0	41.9%
Nominal = [Rate on five-year British government stock	770.5 (1.47)	32.8 (2.48)	0.006 (0.75)	-6.6 (-0.41)	6.8	2.3	38.3%

1. Estimated equation: $I_t = a_0 + a^{\sigma}\sum_{j=1}^{16}\omega_j\ [(P/C)^{\sigma}_t Q_t - (P/C)^{\sigma}_{t-1} Q_{t-1}] + dK_{t-1} + \lambda v_t + et$
2. The critical value for the F-Statistic is approximately 2.34 (6,72 degrees of Freedom, level of significance 95%)
3. No autocorrelation Dw=2, positive autocorrelation Dw<2, and negative autocorrelation Dw>2.
4. The correlation coefficient is adjusted for degrees of Freedom
5. T-Statistic are shown in Parenthesis. Critical value is aproximately 2.00 (72 degrees of Freedom, two tailed test, level of significance 95%).

TABLE 10

The estimation of the Neoclassical Model for the U.K. Manufacturing Sector (Structures, Period 1967:2-86:4)[1]

Different measures of the discount rate that is used to estimate the the Present value of the future stream of Allowances	Constant	$a^{\sigma}\sum_{j=1}^{16}\omega_j$	d	λ	F-Statistic[2]	Durbin-Watson[3] (DW)	R^2 Corrected for autocorrelation[4]
Nominal = Real + 0.3 Inflation	432.8 (0.55)[5]	47.9 (2.75)	0.008 (2.67)	-5.9 (-1.25)	4.7	2.0	47.6%
Nominal = Real + 0.4 Inflation	421.6 (0.55)	34.8 (2.19)	0.004 (2.23)	-4.6 (-0.75)	4.3	2.0	43.2%
Nominal = Real + 0.6 Inflation	615.46 (0.81)	36.2 (2.31)	0.008 (2.39)	-5.3 (-0.5)	4.3	2.0	44.0%
Nominal = Real + 0.7 Inflation	510.4 (0.72)	35.9 (2.23)	0.006 (2.29)	-3.8 (-0.64)	4.3	2.1	43.4%
Nominal = Real + Full Inflation	425.3 (0.55)	29.1 (2.48)	0.005 (2.18)	-4.6 (-0.75)	4.0	2.0	42.5%
Nominal = [Rate on five-year British government stock]	503 (0.66)	18.7 (2.78)	0.007 (2.28)	-3.8 (-0.62)	4.0	2.0	41.3%

1. Estimated equation: $I_t = a_0 + a^{\sigma}\sum_{j=1}^{16}\omega_j \, [(P/C)^{\sigma}_{t}Q_t - (P/C)^{\sigma}_{t-1}Q_{t-1}] + dK_{t-1} + \lambda v_t + et$
2. The critical value for the F-Statistic is approximately 2.34 (6,72 degrees of Freedom, level of significance 95%)
3. No autocorrelation Dw=2, positive autocorrelation Dw<2, and negative autocorrelation Dw>2.
4. The correlation coefficient is adjusted for degrees of Freedom
5. T-Statistic are shown in Parenthesis. Critical value is aproximately 2.00 (72 degrees of Freedom, two tailed test, level of significance 95%).

TABLE 11
The estimation of the Neoclassical Model for the
U.K. Manufacturing Sector (Equipment, Period 1967:2-80:2)[1]

Different measures of the discount rate that is used to estimate the the Present value of the future stream of Allowances	Constant	$a\sigma\sum_{j=1}^{16}\omega_j$	d	λ	F-Statistic[2]	Durbin-Watson[3] (DW)	R^2 Corrected for autocorrelation[4]
Nominal = Real + 0.3 Inflation	759.7 (2.8)[5]	67.9 (2.48)	0.009 (3.53)	-4.1 (-0.76)	11.9	2.0	57.3%
Nominal = Real + 0.4 Inflation	732.1 (2.2)	69.6 (2.43)	0.010 (3.53)	-5.6 (-0.79)	11.7	2.1	58.1%
Nominal = Real + 0.6 Inflation	605.6 (2.2)	69.6 (2.54)	0.009 (3.53)	-5.3 (-0.83)	11.7	2.1	56.9%
Nominal = Real + 0.7 Inflation	661.4 (2.8)	63.0 (2.00)	0.009 (3.52)	-4.9 (0.61)	11.2	2.1	56.6%
Nominal = Real + Full Inflation	643.8 (2.2)	66.8 (2.41)	0.010 (3.52)	-4.7 (-0.63)	10.8	2.1	53.7%
Nominal = [Rate on five-year British government stock	152.6 (0.9)	53 (2.62)	0.008 (2.16)	-7.5 (-0.75)	10.1	2.1	52.0%

1. Estimated equation: $I_t = a_0 + a\sigma\sum_{j=1}^{16}\omega_j\,[(P/C)_t^\sigma Q_t - (P/C)_{t-1}^\sigma Q_{t-1}] + dK_{t-1} + \lambda v_t + et$

2. The critical value for the F-Statistic is approximately 2.34 (6,46 degrees of Freedom, level of significance 95%)
3. No autocorrelation Dw=2, positive autocorrelation Dw<2, and negative autocorrelation Dw>2.
4. The correlation coefficient is adjusted for degrees of Freedom
5. T-Statistic are shown in Parenthesis. Critical value is aproximately 2.00 (46 degrees of Freedom, two tailed test, level of significance 95%).

TABLE 12

The estimation of the Neoclassical Model for the U.K. Manufacturing Sector (Structures, Period 1967:2-80:2)[1]

Different measures of the discount rate that is used to estimate the the Present value of the future stream of Allowances	Constant	$a^{\sigma}\sum_{j=1}^{16}\omega_j$	d	λ	F-Statistic[2]	Durbin-Watson[3] (DW)	R^2 Corrected for autocorrelation[4]
Nominal = Real + 0.3 Inflation	431.5 (2.07)[5]	51.7 (5.64)	0.008 (2.11)	-1.8 (-0.4)	5.8	2.1	71.3%
Nominal = Real + 0.4 Inflation	565.3 (2.49)	65.2 (5.26)	0.013 (2.17)	-2.4 (-0.8)	6.8	1.9	82.5%
Nominal = Real + 0.6 Inflation	416.2 (1.12)	63.1 (5.21)	0.013 (2.31)	-6.1 (-1.45)	6.7	2.0	77.3%
Nominal = Real + 0.7 Inflation	563.5 (2.10)	61.3 (5.49)	0.009 (2.19)	-3.8 (-1.03)	6.3	2.0	75.2%
Nominal = Real + Full Inflation	502.1 (2.21)	57.5 (5.32	0.003 (2.07)	-2.9 (-0.9)	6.1	2.0	74.5%
Nominal = [Rate on five-year British government stock	215.3 (2.17)	31.9 (2.98)	0.009 (2.15)	-2.6 (-0.8)	5.1	2.0	63.7%

1. Estimated equation: $I_t = a_0 + a^{\sigma}\sum_{j=1}^{16}\omega_j\,[(P/C)^{\sigma}_t Q_t - (P/C)^{\sigma}_{t-1}Q_{t-1}] + dK_{t-1} + \lambda v_t + et$

2. The critical value for the F-Statistic is approximately 2.34 (6,46 degrees of Freedom, level of significance 95%)
3. No autocorrelation Dw=2, positive autocorrelation $Dw<2$, and negative autocorrelation $Dw>2$.
4. The correlation coefficient is adjusted for degrees of Freedom
5. T-Statistic are shown in Parenthesis. Critical value is aproximately 2.00 (46 degrees of Freedom, two tailed test, level of significance 95%).

Since the empirical results of this study indicate that no direct relationship between inflation uncertainty and aggregate investment exists, the possibility of an indirect relationship suggested by the theory between those two variables was explored.

This indirect relationship was proved mathematically in chapter VII by combining the investment equation and the modified Lucas-Sargent supply model. Recall from chapter VII that measurement of such effect may be accomplished by evaluating the following derivatives for both equipment and structures.

$$\frac{dI}{d(P_t - P_t^*)} = \gamma \, a^{\sigma} \sum_{j=1}^{16} \omega_j (P/C)_t^{\sigma} \tag{8.3}$$

and

$$\frac{dI}{dV_t} = \lambda \, a^{\sigma} \sum_{j=1}^{16} \omega_j (P/C)_t^{\sigma} \tag{8.4}$$

The first equation (8.3) shows the effect of unexpected inflation on investment, were the latter (8.4) shows the effect of inflation uncertainty on investment. Based upon theoretical grounds the effect of inflation uncertainty on output should be negative and the effect of unexpected part of inflation on output should be positive. Since investment is related positively to output the effect of inflation uncertainty on investment should be negative and the effect of unexpected part of inflation on investment should be positive. However the overall effect on investment should be negative as it was explained in chapter VII and is demonstrated again here by equation (8.5).

$$\lambda \; a^{\sigma} \sum_{j=1}^{16} \omega_j (P/C)_t^{\sigma} - \gamma \; a^{\sigma} \sum_{j=1}^{16} \omega_j (P/C)_t^{\sigma} < 0 \qquad (8.5)$$

In order to evaluate equation (8.5) we need estimation of $\lambda, \gamma, a^{\sigma}\Sigma\omega_j$ and $(P/C)_t^{\sigma}$, for both equipment and structures.

Parameters λ, which is the coefficient of unexpected part of inflation, and γ, which is the coefficient of inflation uncertainty in the modified Lucas Sargent supply curve presented in (7.3) can be estimated by employing the OLS method, and the results are presented in Table 13.

The results shown in Table 13 indicate that all coefficients are significantly different than zero at 95% level of significance. Also the explanatory power of the model is relatively high and equal to 65.3%. From these results it can be seen that the unexpected inflation is positively related to output and the inflation uncertainty has a negative relationship with output.

TABLE 13

The effect of unexpected inflation and inflation uncertainty on output (period 1967:2-1980:2)[1]

constant	2.06 (2.52)[2]
output coefficient	0.72 (9.54)
unexpected inflation	0.67 (2.41)
inflation uncertainty	- 0.72 (2.68)
R^2 (adjusted for degrees of freedom)	65.3%

1. Estimated equation : $Q_t=a+Q_{t-1}+\gamma(P_t-P_t^*)+\lambda V_t+et$ (the definition of variables are given in chapter VII)
2. T-static are shown in parenthesis. Critical value is approximately 2.00 (46 degrees of freedom, two tailed test, level of significance 95%)

These results are in line with theory and the empirical findings of Levi and Makin (1979,1980), Mullineaux (1980).

Finally in order to evaluate equation (8.5) and with estimates of $a^{\sigma}\Sigma\omega_j$ obtained from table 5 we need values for the price of output P and the user cost of capital C for both equipment and structures.

However we need not concentrate on a specific time period for values of P and C since from equation (8.5) we can see that the ratio P/C is the same in both terms of the equation; and with the assumption of the OLS method, according to which, the coefficients λ, γ, $a^{\sigma} \sum_{j=1}^{16} \omega_j$ remain constant thought time, it is apparent that the difference

$$\lambda\ a^{\sigma} \sum_{j=1}^{16} \omega_j (P/C)_t^{\sigma} - \gamma\ a^{\sigma} \sum_{j=1}^{16} \omega_j (P/C)_t^{\sigma}$$

will remain constant through time.

By making the appropriate substitutions in equation (8.5) we arrive at the following result :

First for equipment, the effect of inflation uncertainty on investment through output is -0.2% and second for structures, the effect of inflation uncertainty on investment through output is -0.1%.

Therefore the above results confirm the hypothesis that inflation uncertainty is a significant determinant of investment. Although these effects are much smaller than the measured effects of inflation and historic cost depreciation on investment (Tables 6-8) they are nevertheless relevant to the explanation of recent business behaviour.

8.4 Conclusion

As stated in the introduction, the purpose of this empirical research is to provide the evidence necessary to answer four questions : (1) Does inflation lead to a significant decline in business investment?, (2) is the negative impact of inflation on investment greater for equipment than for structures?, (3) Are the effects of inflation on investment constant under different economic conditions?, and (4) Does an increase in inflation uncertainty have a negative impact on business investment? The data provided by this study indicate affirmative answers to each of these questions, suggesting that both inflation and inflation uncertainty are determinants of both the level and composition of investment demand.

The empirical evidence provided by this chapter supports the result of chapter IV that the decline in the real value of depreciation deductions brought about by inflation leads to a decline in real business investment. Such effects result from the interaction of inflation and tax depreciation rules which require historic - cost evaluation of assets. Investment in both equipment and structures is affected by this distortion even at low rates of inflation as shown in

Tables 6-8. In general, the evidence supports the hypothesis that inflation is partly responsible for recent weak growth in aggregate business investment.

Further, the evidence in this study also supports the hypothesis that inflation leads to a much greater decline in equipment than in structures investment. This result persists over a wide range of economic conditions, substantiating the predictions of chapter IV. From this evidence, I conclude that inflation does not explain the recent increase in the share of manufacturing investment devoted to equipment purchases as suggested by Corcoran (1979), Feldstein (1981), and Kopcke (1981).

In addition, the data presented in this chapter demonstrate that the influence of inflation on investment is likely to change over time. The sensitivity of equipment and structures investment to inflation varies substantially with changes in real finance rates and real asset purchase prices, as indicated by the data in Tables 6-8. This finding confirms the idea that proper measurement of the effects of inflation on investment is critically dependent on the assumed economic conditions of the period. Changes in investment brought about by changes in inflation are jointly determined with several additional economic factors. The discussion in chapter V demonstrates that failure to account for this fact leads to improper econometric specifications and misleading empirical results.

Of equal importance is the conclusion regarding the effect of inflation uncertainty on investment. Based on the econometric results presented in this chapter, I conclude that an increase in inflation uncertainty results in a decline in manufacturing investment although these effects are much smaller than the measured effect of inflation. This finding is consistent with the assertions by Friedman (1980), Malkiel (1979) and Cuckierman (1981) that increase, in inflation uncertainty negatively affected economic activity, and with the empirical results of Mullineaux (1981), who finds that increases in inflation uncertainty reduce industrial output. The present study indicates, however, that Mullineaux's broad empirical results mask a more interesting relation between inflation uncertainty and a sectoral component of output, namely investment.

CHAPTER IX

CONCLUSION

The purpose of this research is to measure directly the effects of inflation and inflation uncertainty on the level and composition of U.K. manufacturing investment. Chapter 2 has discussed a number of issues relating to the effects of inflation, in an attempt to improve our understanding of the environment under which business firms operate. In particular, attention was focused, on the real effect taxes have on firms in an inflationary economy, as a result of a tax system, that is not fully indexed for inflation. Furthermore evidence have been presented on the effect of inflation on interest rates and the negative impact it has to the prices of common stock. Specifically it was shown that the above relations are best achieved only when the effect of inflation on other macroeconomic variables is examined and their interrelationship is understood.

Chapter 3 presented several recognized variations of the theory of investment behaviour. Each method seems to provide a reasonable explanation of investment activity. However because of the focus of the study, the neoclassical econometric model of investment is relevant to the problem of quantifying the effects of inflation and historic cost depreciation on investment, because the model is derived from conditions of profit maximization by a neoclassical firm, which changes in investment behaviour can be traced to changes in cost. Therefore it is appropriate to predict that net and gross investment will react to specific economic conditions such as inflation which determine user cost.

The results of chapter 4 suggest that inflation reduces business investment by reducing the real value of depreciation deductions based on historic cost asset values. Chapter 4 also demonstrates that the effects of inflation on investment will be greater for equipment than structures capital, and that such effects will vary according to different initial assumptions about real finance rates and asset purchase prices. In addition the discussion in chapter 5 suggests that increases in inflation uncertainty lead to reductions in business investment, brought about by increased hurdle rates, greater planning costs, and an overall slower rate of economic activity.

The major problem in assessing the significance of these factors is the clear lack of economic evidence regarding these topics. Essentially, the hypothesis that inflation and inflation uncertainty distort the level and composition of business investment has not been subjected to rigorous empirical examination. This research is designed to supply data necessary to evaluate the importance of these factors as determinants of investment.

The methodology used in this study is based on the econometric estimation of neoclassical investment equations for the U.K. manufacturing industries. Separate equations are estimated for equipment and structures for the period 1967:2 - 1986:4. Explanatory variables in the models are constructed to allow for explicit treatment of inflation expectations and inflation uncertainty. Estimation of these equations provide direct empirical tests of the hypotheses that inflation uncertainty and the user cast of capital are significant explanatory variables for manufacturing. Coefficients from these equations are then used to simulate the effects of changes on inflation and inflation uncertainty on manufacturing investment.

From the data provided by this research four basic conclusions are reached. First, the empirical evidence supports the hypothesis that the decline in the real value of depreciation deductions brought about by inflation leads to a decline in real business investment. The data suggests that such effects are substantial, and that failure to account for the interaction of inflation and historic cost depreciation leads to incorrect predictions of investment. This result also supports the contention by Hendershott and Hu (1981a), Feldstein (1981a), and Kopcke (1981) that inflation is responsible for the recent decline in net investment. Second, the evidence in this study supports the hypothesis that inflation leads to a much greater decline in equipment than structures investment. This finding is consistent with Hendershott and Hu (1981c), but runs counter to the analysis of Feldstein (1981a) and Kopcke (1981). This result persists over a wide range of economic conditions, indicating that the recent shift on the composition of business investment toward equipment is not explained by increases in inflation. Third, the data also confirm the hypothesis that the effects of inflation and historic cost depreciation on investment will vary over time. Changes in investment brought about by changes in inflation are jointly determined with real finance rates and asset purchase prices, and proper measurment of such effects is critically dependent on additional economic variables.

Finally, the evidence obtained by this research confirms the hypothesis that inflation uncertainty is a significant determinant of investment demand. Increases in inflation uncertainty reduces manufacturing investment and distorts the composition of manufacturing investment towards structures. These effects are much smaller than the measured effects of inflation and historic cost depreciation on investment, but they are nevertheless significant.

This research is unique for two reasons. The results obtained in chapter 4 contribute to the resolution of the controversy surrounding the effects of inflation on investment composition. The hypothesis of Feldstein and Kopcke that inflation biases investment toward equipment is shown to be ambiguous in theoretical terms. This ambiguity is resolved, however, when the effects of inflation on relative costs of investment are examined within the framework of the user cost of capital as shown by Hendershott and Hu (1981c). The analysis also discusses the conditions under which the predicted composition effects of inflation could be reversed, an idea that has not been discussed in the literature.

Finally, and most importantly, the empirical results in this thesis represent the only econometric evidence available to measure the significance of inflation and inflation uncertainty on investment. The evidence provided by this research suggests that both of these factors are important elements in the recent decline in net investment and growth of the capital stock, and that failure to account for these variables leads to serious specification errors.

Concluding this study forms the basis for further research on the effects of inflation on investment in manufacturing industry. A possible suggestion could be to examine the effects of inflation on investment by using a cross section time series approach in order to capture the individual characteristics across manufacturing industries. In addition similar analysis could be performed for different countries and their results compared.

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